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A COMPETITIVE ASSESSMENT OF THE U.S. ELECTRIC POWER GENERATING EQUIPMENT INDUSTRY

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Prepared By

Capital Goods and International
Construction Sector Group

International Trade Administration
U.S. Department of Commerce

October 1985

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FOREWORD

The following competitive assessment of the electric power generating equipment industry is intended to inform decision-makers in the Executive and Legislative Branches of the problems and prospects of this industry. The assessment is meant to inspire debate on the issues which could lead to new ideas and perhaps a consensus on an appropriate course for U.S. Government policy with respect to this industry. Comments on this assessment may be addressed to the attention of:

Deputy Assistant Secretary
Capital Goods and International Construction
Room 2001B
U.S. Department of Commerce
Washington, D.C. 20230

The scope of the assessment includes the equipment which comprises principal components of electric power generation plants--power boilers (SIC 34433, 34436) and turbine generator sets (SIC 3511).

Sources of resource data and information include the International Trade Administration, Bureau of Census and Bureau of Economic Analysis of the U.S. Department of Commerce; Bureau of Labor Statistics, Department of Labor; and the Department of Energy. In the course of this assessment, advice and comments were sought from the private sector, including the Edison Electric Institute, the Electric Power Research Institute, the North American Electric Reliability Council, and the Tennessee Valley Authority.

The assistance and information provided by individuals within these organizations is gratefully acknowledged. Responsibility for the analysis and findings in this report remains with the U.S. Department of Commerce.

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EXECUTIVE SUMMARY

The United States is still the leading producer and consumer of electricity in an increasingly competitive world. In 1984, total installed electric power generation capacity in the United States, 674 gigawatts, was 31 percent of total world capacity.

There is no doubt that the electric power generating equipment industry is essential to the U.S. economy. Practically every U.S. industrial, residential, and military installation depends, in a major way, on the electricity generated by the equipment covered in this report. The equipment comprises principal components of electric power generation plants: power boilers and turbine-generator sets. The study covers equipment for electric power generated in thermal steam power plants using coal, gas, and oil, or nuclear material as a heat source; and gas turbine-generators and hydroturbine generators.

The U.S. share of world power generating equipment exports has eroded from 21.3 percent in the 1955-75 period to 12.5 percent in the period since 1975. Furthermore, the U.S. share of the turbine-generators' world market declined from 51.3 percent in the 1970-73 period to 45.4 percent in the 1978-81 period.

Foreign producers have made significant inroads in the U.S. market. Since 1970, 43 percent of U.S. hydrogenerator demand has been supplied by foreign manufacturers; 23 percent by Japanese companies; 11 percent by Canada and 9 percent by Western Europe. Moreover, foreign producers have captured 10 percent of the U.S. steam turbine-generator market.

Competitiveness of U.S. Industry

Despite continuing U.S. world leadership in this industry, there are a number of difficult interrelated factors which critically affect both the short- and long-term prospects for the industry:

- -- low levels of domestic demand;
- -- limited access to markets in Europe and Japan;
- -- impediments to developing country markets due to the existence of the International Electrical Association;
- -- high interest rates and high value of the U.S. dollar; and
- -- a very difficult regulatory climate at the state level where rates of return for electric utilities have been kept low and at the federal level where regulation of fossil plants and nuclear technology has delayed nuclear power adoption at home and its export abroad.

Slowed Demand Growth

The primary problem facing equipment manufacturers is the moderation of worldwide demand growth for electricity with a consequent excess production capacity in the power generating equipment industry. This slowing of demand growth stemmed from energy conservation efforts and economic slowdowns precipitated by skyrocketing oil prices beginning in 1973. Fewer than expected orders have intensified worldwide competition for equipment sales.

With future world economic growth predicted to be minimal over the next few years, a major concern in the longer run is that slowed demand growth may not produce enough orders for sufficient revenue to encourage the level of industrial research and development vital to maintain a technological edge over competitors. Demand problems have been further compounded by the high value of the dollar and debt liquidity crises in developing countries.

Other Factors

High interest rates have seriously hampered U.S. suppliers. Suppliers complain that sometimes they are unable to conclude export deals because of non-competitive Eximbank financing compared to lower foreign interest rates and mixed credits. High interest rates may also constrain capital formation in plant modernization and technological improvement and increase production costs because of high inventory carrying costs.

Also, in the United States, it is not customary for government, electric power equipment manufacturers, constructors and architect engineers to jointly develop and market projects. In contrast, there is a closer, more cooperative relationship in European industry, some of which is government-owned, and between the highly integrated Japanese firms and their government. This cooperation between industry and government in Europe and Japan impedes U.S. penetration of domestic and third-country markets. The IEA, through market allocation among its members, complicates penetration of developing country markets by U.S. firms.

A special problem is the U.S. public's negative perception of nuclear energy and lengthy and complex government regulation of the industry. These conditions directly affect potential demand for domestic and exported nuclear electrical generating equipment.

Industry Approaches

The U.S. heavy electric generating equipment industry has tried to cope with its problems through a combination of approaches.

U.S. suppliers are expecting only a moderate demand growth rate for power generating equipment in the U.S. market, on the order of 2-3 percent in the remainder of the decade. In addition, they are facing continued minimal export opportunties in Western Europe and Japan because of longstanding non-tariff barriers, and they are therefore, focusing more on markets in developing countries.

In spite of the current debt liquidity crisis and the expenditure cut-backs by oil-rich Middle East nations, these markets are recovering from historic purchasing lows and substantial business is available. However, it is a buyers' market generally characterized by subsidized export financing and importer requirements for technology transfer. All major world suppliers have been forced to accede to this latter condition and U.S. suppliers must also if they are to share in the market. Typically in these transactions, once a local entity is engaged, that host country closes its border and all suppliers other than the technology transferor are excluded. This means that a single transaction may result in the successful bidder sharing a significant part of a country's business for 10-15 years. Non-U.S. suppliers have a decided advantage in that they can include narrow geographic restrictions in the license agreement for the transferred technology, while U.S. antitrust laws do not allow U.S. firms to be as restrictive.

U.S. manufacturers have also entered joint ventures. One such joint venture with the Japanese involves the development of advanced nuclear reactor systems. The resulting technology will be available to both the U.S. and Japan but the first systems will most likely be built in Japan since they have the first need.

In order to sustain leadership in technology and productivity, the industry is evaluating and adopting improvements, including upgrading of current facilities, smaller plants, cogeneration, high temperature gas turbines, pumped storage systems, combined gas and steam turbine systems, supercooled generators, fluidized bed combustion, coal gasification/gas/steam turbine systems, and advanced light water nuclear systems.

Conclusions

Significant increases in U.S. domestic demand are not expected in the next decade. Rather U.S. firms will have to look towards developing country markets for business. However, factors such as a strong U.S. dollar, lack of competitive financing and competition from IEA competitors will put U.S. firms at a competitive disadvantage in these markets.

A number of options for government action to assist the industry have been identified including greater access to European and Japanese markets, marketing and financing assistance in developing country markets, increased funding for research and development, and tax credits, with attendant budgetary implications. This assessment provides background for evaluating the need for and effectiveness of specific government activities.

I. INDUSTRY AND PRODUCT DESCRIPTION

Product Definition

The equipment covered by this report comprises the principal components of electric power generation plants. The principal components are power boilers or steam supply systems (nuclear and conventional SIC 34433, 34436) and turbine-generator sets (SIC 3511). Power boilers and turbine generator sets are well-defined products and are exclusively used in electric power generating plants.

Electricity is generated in different ways. The major portion, 78 percent, is generated in thermal power plants which use fossil fuels--coal, gas and oil--or fissioning uranium as their heat source. Gas turbine and diesel engine-driven generators are also thermal plants, accounting for a small but important part of the 78 percent. Hydroturbine-generators supply 22 percent of the world's electricity by converting the water power stored by large dams into electrical energy.

The equipment produced by this industry is large, heavy, and, for the most part, custom-designed. It is manufactured in specialized factories and requires major erection and assembly effort at its ultimate operating site. However, boilers or steam supply systems require extensive welding and assembly of many parts while turbines usually require the careful assembly of only a few very large pieces.

This difference in "localization" of the final product results in different marketing techniques. When marketing a turbine, the technology of turbine manufacturing may exclude local content; the marketing of boilers takes local content into account. With boilers, it is the design specifications that are critical, not the actual manufacturing.

Steam Supply Systems

Boilers convert various energy sources into steam energy. They are best classified by their energy source. Conventional steam supply systems burn fossil fuels--gas, oil or coal. Nuclear boilers utilize the energy from fissioning uranium to generate steam. Modern terminology identifies boilers as nuclear or fossil-fired steam supply systems.

Domestic manufacturers of electric utility sized conventional steam supply systems include Babcock and Wilcox, Combustion Engineering, Foster Wheeler, and Riley Stoker. Nuclear steam supply systems are produced by Babcock and Wilcox, Combustion Engineering, General Electric and Westinghouse. Combustion Engineering initially participated in the nuclear power market as a supplier of major components to both General Electric and Westinghouse. They later made a successful entry into the market with a complete nuclear steam supply system of their own design. A review of the world's currently active nuclear power projects indicates that U.S. exports of systems have been sold primarily by General Electric and Westinghouse. They may soon be joined by Combustion Engineering.

Turbine-Generator Sets

Steam Turbines and Generators--Steam energy is converted to electrical energy by a turbine-generator set. Generally, sets appear to be six individual machines. The first four make up the "turbine" which usually consist of one high, one intermediate and two low pressure units. Turbine units are coupled to a generator. The generator rotor (or field) is, in turn, usually coupled to an exciter which provides the generator field current required to produce electricity in the stationary portion of the generator. Different arrangements of turbines, generators, and exciters are possible so that the overall length of base load sets can range from 130 to 250 feet. Units are custom-tailored, high technology products produced in capital intensive facilities.

Two firms account for virtually all of the domestic production of electric utility sized steam turbine-generator sets--General Electric and Westinghouse.

Hydroturbines and Generators--Hydroturbines are used to drive electric utility sized generators. Hydroturbine generator sets are physically large, custom-designed units that are fabricated and partially assembled in a manufacturing facility. Factory built components are shipped to the operating site where they are erected and assembly is completed.

No U.S. manufacturer produces both hydroturbines and hydrogenerators. Until recently, Allis-Chalmers' Hydroturbine Division, located in York, Pennsylvania, was the sole domestic company capable of complete development, design and manufacturing of utility-sized hydroturbines. Combustion Engineering has now joined

the field through a joint venture with Neyrpic of France. Named CE-Neyrpic, this firm has established itself as a domestic manufacturer by licensing technology from Neyrpic, performing design work in the United States and utilizing Combustion Engineering manufacturing facilities to produce hydroturbines. Hydrogenerators are produced by Siemens-Allis, currently in Allis Chalmers' Wisconsin facilities and soon-to-be in Florida facilities scheduled for completion in 1985. Westinghouse has domestic hydrogenerator production facilities, but is not presently bidding on new contracts, and General Electric fulfilled its last large contract in its Canadian facilities.

Gas Turbines and Generators--Early power generating gas turbines were small, heavy-duty units basically designed for other applications such as pumps and compressor drive units for pipeline and process applications. They operated at high rotational speeds and drove their mating generators through a speed reducing gear box. Larger, lower speed gas turbines have been developed for electric utility application. The larger, lower speed units better match utility requirements, provide greater durability, and eliminate the need for a speed-reducing gear box. In recent years, aircraft derivative gas turbines, using specially designed power turbines, have been used by utilities particularly in standby and peaking applications.

Manufacturers developed an expanded role for gas turbines by introducing the gas/steam turbine combined cycle plant. This system directs the hot gas turbine exhaust to a waste heat steam boiler from which a steam turbine-generator set is driven. The combined cycle makes more efficient use of energy than conventional thermal systems. Currently, gas turbines require petroleum or gaseous (i.e. natural gas) fuel for satisfactory operation. Oil price increases launched by OPEC in 1973 have, generally, limited gas/steam turbine combined cycle units to locations having an abundant supply of low cost natural gas or petroleum fuel. The recent abundance of oil and decline in its price has slowed the development of sophisticated systems by reducing the economic incentive. Currently, gas turbines play a limited role in electric power generation accounting for about 8 percent of U.S.-installed capacity and generating about 0.6 percent of its electricity. Gas turbine-generator sets are manufactured by General Electric, the Solar Division of Caterpillar, and by Westinghouse. Gas turbine-generator sets are also supplied by firms that assemble components manufactured by others. United Technologies, General Electric Aircraft Engine Group, and the Detroit Diesel Allison Division of General Motors are the principal manufacturers of aircraft derivative gas turbines for these sets. Delco, Electric Machinery and others supply the mating generators.

Profile of U.S. Producers

The major U.S. producers of electric power generating equipment include General Electric, Westinghouse, Allis-Chalmers, Combustion Engineering, Foster-Wheeler Corporation, and Babcock and Wilcox International, a subsidiary of McDermott International.

General Electric

G.E.'s Power Systems Sector includes gas and steam turbines and generators, nuclear power equipment and services, power delivery, and construction and engineering services. According to its 1983 annual report, G.E. foresees a major developing future market in electric power generating equipment in cogeneration[1] and an emphasis on products and services that permit utilities to employ existing capacity more productively and profitably. Examples include the large steam turbines upgrade program which would increase the reliability and efficiency of older turbines at a fraction of the cost of a new one and nuclear "barrier" fuel which improves boiling water reactor plant utilization.

A major 1983 project for G.E.'s Power Sector was the $100 million joint venture with Big Three Industries to own and operate a 300 megawatt cogeneration plant in Texas. General Electric supplied the major equipment elements for this project, one of the largest cogeneration projects undertaken.

Turbine earnings were up in 1983 due to increased export sales and substantially improved operating margins reflecting productivity improvements. Expenditures to improve productivity and efficiency exceeded $170 million in 1983, up 15 percent from 1982.

G.E. Power Systems exports included gas and steam turbines and heat recovery steam generators to the Tokyo Electric Power Co. of Japan for the world's largest combined-cycle power facility. General Electric also produced generating equipment for a Romanian power plant and a significant number of gas turbines for Saudi Arabia.

Westinghouse

Electric power generating equipment is produced by the Energy and Advanced Technology Group in Westinghouse, along with defense electronics, industrial robots and people-moving transportation systems. This range of products should be kept in mind when reviewing financial data on Westinghouse throughout this report.

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[1]See section V for a discussion of cogeneration.

In 1983 Westinghouse won the first steam turbine-generator contract placed by a U.S. utility in 2 years. Westinghouse also signed contracts with China to supply technology, engineering services, parts and components for a turbine generator. However, Westinghouse received no new nuclear generating plant orders in 1983 due to the overall lack of demand in the U.S. and worldwide.

Recent Westinghouse involvement in foreign projects includes an agreement in principle with Japan's Mitsubishi Heavy Industries Ltd. for the design of an advanced nuclear power reactor; sales of power generating equipment to Saudi Arabia, Egypt, Mexico and China and a technology transfer agreement with France's Framatone, a nuclear power plant manufacturer.

Combustion Engineering

Combustion Engineering Power Systems Group supplies equipment and services for fossil fuel and nuclear steam generating systems for electric utilities and general industry.

Combustion Engineering serves the domestic and international markets for steam generating systems and is expanding its activities in the servicing of previously installed fossil and nuclear steam generating equipment. Expanded services include availability improvements, load regain programs, safety and reliability modifications, and efficiency improvements.

Financial performance in C-E's utility business improved in 1983 as a result of expanded services, but it was necessary to reduce manufacturing capacity and employment to match the reduced utility markets.

Combustion Engineering Power Systems Group has a network of 46 licensees and associated companies in thirty countries. C-E maintains 20 manufacturing plants and 6 research and development facilities in the United States and Canada.

Total export sales for Combustion Engineering, Inc. declined from $432.5 million in 1981 to $350.2 million in 1983. Foreign sales by foreign subsidiaries and domestic subsidiaries (located in foreign areas) also declined from $784.2 million in 1981 to $654.8 million in 1983.

Allis-Chalmers

Allis-Chalmers is a major producer of hydraulic turbines. The company has produced over 12,000 hydraulic turbines in the U.S. and in 36 foreign countries.

Allis-Chalmers, as a leader of an international consortium, was recently awarded a $260 million contract for the Yacyreta project in Argentina. This follows two other recent contracts for hydraulic turbines in Argentina: a $38.7 million contract for the Rio Grande project and a $20.5 million contract for the Alicura project, both of which are expected to be completed in 1985.

In addition, Allis-Chalmers is currently manufacturing turbines under a $22.8 million contract for the Aswan II project in Egypt. The company was also selected, based on technological capabilities, for a negotiated contract to replace the faulty Russian runners in the Aswan high dam. This decision, by Egyptian authorities, was supported by a mixed credit financing arrangement through AID and the Eximbank. The total contract for this effort is valued at $62.6 million.

Allis-Chalmers is also the manufacturer of the world's largest hydraulic turbines in excess of one million horsepower each at the Bureau of Reclamation Grand Coulee Dam.

Foster Wheeler

Foster Wheeler Energy Equipment primarily designs and fabricates steam generators and condensers. This division of Foster Wheeler has manufacturing plants in New York, Ontario, England and Ireland with subsidiaries in Australia, Canada, the United Kingdom, France, Ireland, Italy, Saudi Arabia, Spain, Switzerland and Turkey.

Foster Wheeler Energy Equipment's major projects for 1983 included: Ford Motor Co. Ltd's $24 million purchase of four coal-fired boilers for their plant in Dagenham, England; the design, fabrication, construction and commissioning of a 660,000 lbs/hour coal-field steam generator by Enemalta Corp. Ltd. on the island of Malta; and Foster Wheeler Ltd. Canada's $15 million contract to rebuild the first of three boilers and perform other steam plant maintenance at Suncor's Alberta oil sands plant.

Foster Wheeler also received a $14 million contract in 1984 for the design, engineering, equipment procurement and construction of a cogeneration power plant at a corn refining facility in Sagamore, Indiana.

Sixty-three percent of Foster Wheeler Energy Equipment revenues for 1983 were from domestic subsidiaries, up from 57 percent in 1979.

Babcock & Wilcox

Babcock and Wilcox is a subsidiary of McDermott International Power Generation Systems and Equipment Division. It manufacturers complete fossil fuel boilers, nuclear steam supply systems, and nuclear fuel and nuclear fuel assemblies for the electric utility industry. Most plants are owned by Babcock and Wilcox and are located in the United States with the exception of one in Ontario, Canada.

The electric utility industry accounted for 27 percent of McDermott International total revenues in 1983, while the U.S. Government accounted for 9 percent of McDermott International's total revenues that same year. In particular, the Navy's nuclear shipbuilding operations are an increasingly important part of this division's business. In addition, the Power Generation Systems and Equipment Division's backlog with the U.S. Government is 30 percent of the total McDermott International backlog of $4.1 billion.

Revenues, capital expenditures, backlogs, and employment figures for this industry are analyzed in section II.

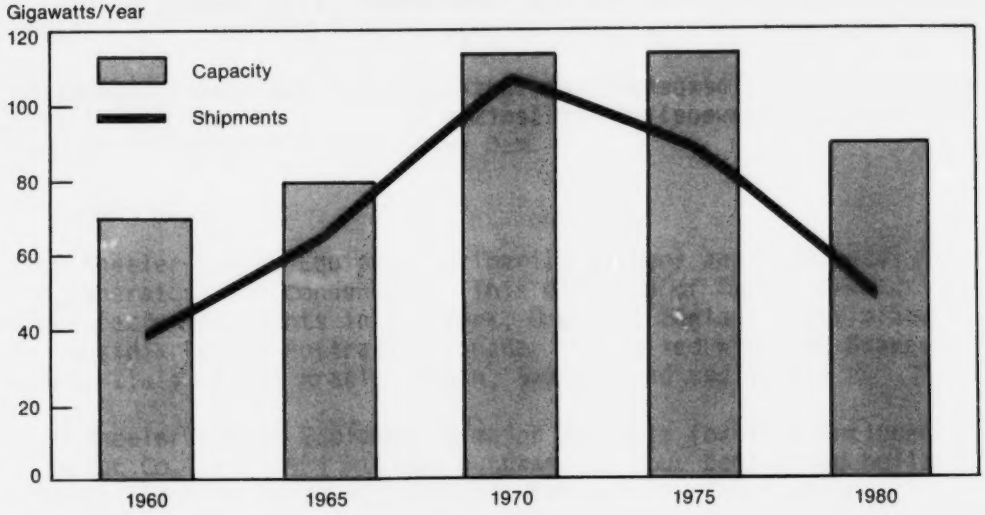
II. U.S. INDUSTRY PERFORMANCE

Industry Demographics

The power generating equipment industry is distinguished by high fixed-costs and comparatively large overheads. In order to operate at even a break-even point, a certain level of manufacturing must be maintained. These basic economics of the industry currently have resulted in a significant over-capacity.[2] Figure 1 illustrates this point for steam turbine generators. In 1970, when shipments were at a peak, shipments were approximately 93 percent of total manufacturing capacity. In 1980, shipments were only 52 percent of capacity and have declined further since then.

FIGURE 1

Free World Steam Turbine Generator Manufacturing Capacity



Source: "A Business Assessment of Power Generation Technological Opportunities: Stage 1", Hayes/Hill Incorporated, Chicago, Illinois; under contract to the U.S. Department of Commerce; September 1984.

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[2] "A Business Assessment of Power Generation Technological Opportunities: Stage 1,"; Hayes/Hill Incorporated, Chicago, Illinois, under contract to the U.S. Department of Commerce; September 1984.

According to the 1982 Census of Manufactures, the turbine and turbine generator set industry is made up of 88 establishments, 49 of which have 20 employees or more. The industry employs 32.6 thousand including 18.8 thousand production workers. This figure is 20 percent below the 40.8 thousand reported in 1977. Seventy-five percent of the employment in 1982 was in New York, Pennsylvania, Massachusetts and California. The specialization ratio (the ratio of primary products to total products shipped) of establishments in this industry is 94 percent.

A breakdown of the power boiler industry per se is not available. The statistics on number of establishments and employment below include all fabricated plate work (boiler shops). However, for the purpose of perspective, product shipments for 1982 for SIC 34433 and 34436 represented 20 percent of total SIC 3443 product shipments. The following data in parentheses is an estimate of SIC 34433 and 34436 data based on this 20 percent. Industry 3443 is made up of 1,926 (385) establishments with 965 (193) having 20 employees or more according to the 1982 Census of Manufactures. Employeed in this industry are 103.2 (20.6) thousand total employees, 73.5 (14.7) thousand of which are production workers. This total employment figure is 16 percent below that reported in 1977. Texas, Pennsylvania, Ohio and Oklahoma are the leading states for employment in this industry. The establishments in this industry have a 93 percent specialization ratio.

Product Shipments

Table 1 provides relevant product shipment data for SIC 3511 and SIC 34433, 34436 in current and constant dollar amounts. Tables 2 and 3 and Figures 2 and 3 provide shipment, new order, backlog and trade data in megawatts for turbine-generators and boilers.

Current dollar product shipments of turbines and turbine generator sets peaked in 1983. However constant dollar shipments peaked in 1979 with changes in constant dollar figures amounting to a 10 percent decrease from 1977 to 1983.

Current dollar product shipments of conventional and nuclear power boilers increased each year over the period 1977-1981 a total of 20 percent. However, in 1982, shipments decreased 20 percent from the previous year and decreased another 1 percent in 1983. In terms of constant dollars, product shipments of conventional and nuclear power boilers decreased steadily from 1977 to 1983 a total of 43 percent.

In terms of megawatts, during the period 1972-1983, shipments of turbine-generators declined 75 percent. This overall decline applied to steam, gas and hydro as displayed in Figure 2. The market for U.S. manufactured turbine-generators is dominated by shipments to U.S. customers. Exports, in volume, were a minor consideration until 1983 when overall shipments had declined so that exports then represented 49 percent of total shipments. Turbine-generator shipments declined precipitously even though the backlog and new orders, for a time, remained sufficiently high to justify a higher level of deliveries.

Shipments of boilers in terms of megawatts declined significantly over the 1972-1983 period, dropping 56 percent overall.

TABLE 1

PRODUCT SHIPMENTS IN DOLLARS
(Millions of Dollars)

	1977	1978	1979	1980	1981	1982	1983
SIC 3511 Turbines and Turbine Generator Sets							
Current Dollars	2813	2824	3211	3601	3787	3676	4172
Constant $1972	1668	1547	1702	1619	1491	1393	1533
SIC 34433, 34436 Conventional and Nuclear Power Boilers							
Current Dollars	1656	1718	1810	1950	1983	1591	1584
Constant $1972	1022	982	948	895	851	603	582

Source: Bureau of the Census, U.S. Department of Commerce

TABLE 2

U.S. TURBINE - GENERATOR SHIPMENTS, NEW ORDERS, BACKLOG AND CANCELLATIONS
(Steam, Hydro, Gas)
(Megawatts)

	Shipments		New Orders		Backlog		Cancel-lations
	Total	Exports	Total	Exports	Total	Exports	
1972	51,872	995	74,054	10,888	188,903	17,211	4,701
1973	43,507	6,062	88,771	7,822	229,466	18,991	3,891
1974	44,270	6,746	96,580	9,418	270,159	21,380	11,618
1975	33,348	5,007	19,467	3,736	246,531	19,978	9,746
1976	37,646	8,089	25,785	5,299	229,532	17,170	5,139
1977	30,956	2,486	17,112	1,109	205,858	15,782	9,830
1978	29,487	2,869	21,757	1,285	185,784	12,055	12,344
1979	31,970	5,208	9,559	3,576	152,054	14,382	11,319
1980	23,190	7,552	7,711	4,331	132,060	14,573	4,583
1981	16,413	2,847	12,850	4,531	108,310	17,029	20,187
1982	10,894	3,303	638	213	83,495	14,240	13,896
1983	12,920	6,372	3,418	674	67,477	8,543	6,516

Source: Edison Electric Institute

TABLE 3

U.S. CONVENTIONAL & NUCLEAR BOILER SHIPMENTS, NEW ORDERS BACKLOG AND CANCELLATIONS
(Megawatts)

	Shipments		New Orders		Backlog		Cancel-lations
	Total	Exports	Total	Exports	Total	Exports	
1972	29,941	1,303	66,566	5,902	209,397	23,054	2,013
1973	29,058	1,728	78,330	4,425	255,787	25,387	2,882
1974	32,585	3,316	80,616	8,446	280,341	30,561	23,477
1975	27,152	3,252	33,394	10,581	271,520	37,975	15,063
1976	23,958	562	12,172	4,998	249,125	37,088	10,609
1977	23,460	2,540	15,475	3,234	230,836	37,766	10,304
1978	19,512	3,379	24,330	5,661	221,275	38,076	14,379
1979	15,539	5,623	3,960	1,537	204,616	35,693	5,080
1980	18,394	3,538	13,625	2,733	189,128	35,026	10,719
1981	12,530	3,803	9,575	1,810	178,241	34,779	7,932
1982	13,111	2,980	212	none	153,495	31,798	11,847
1983	13,178	3,800	673	none	128,306	27,999	12,684

Source: Edison Electric Institute

FIGURE 2

U.S. Shipments Turbine-Generators

(Total, Steam, Gas & Hydro)

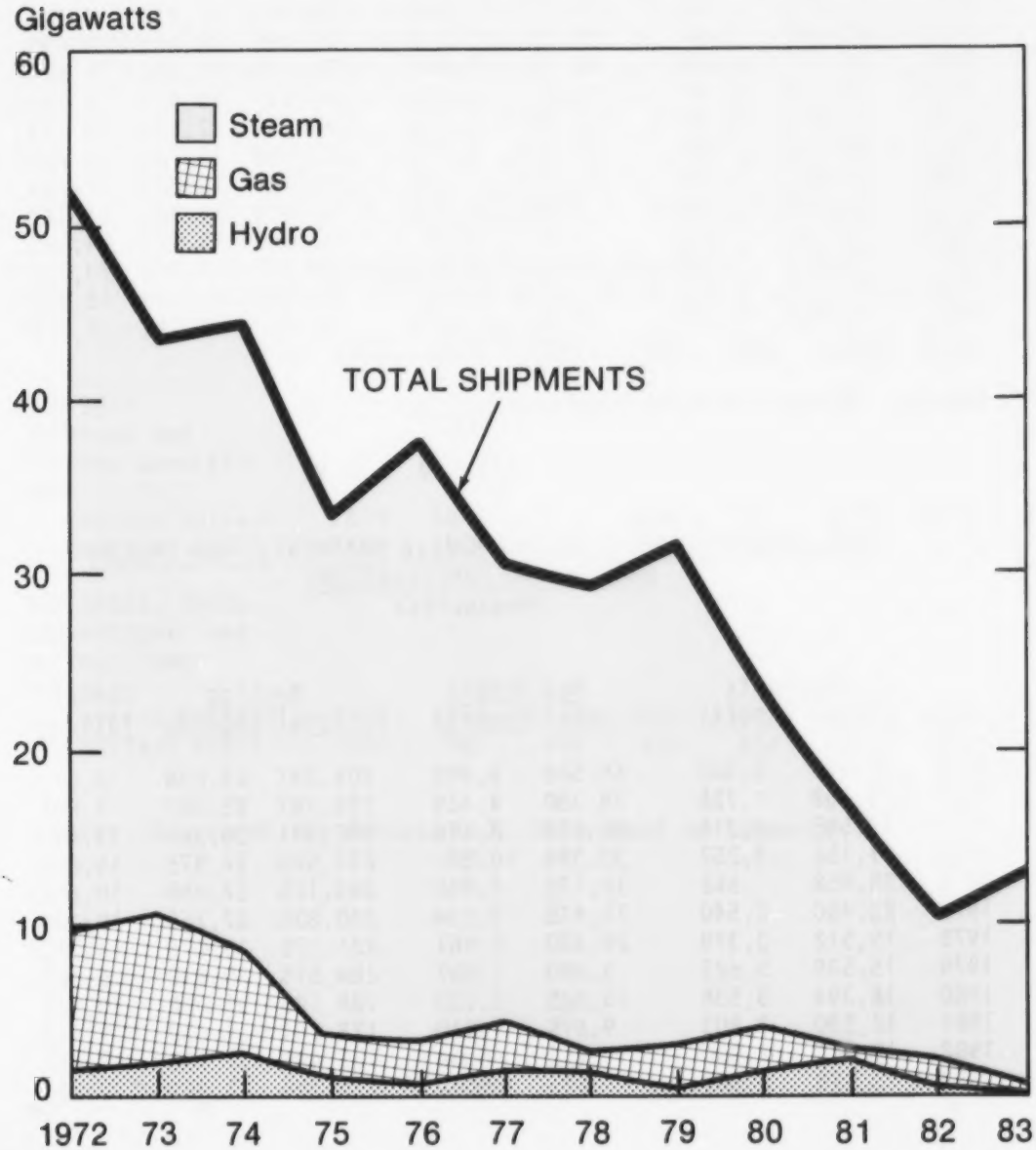
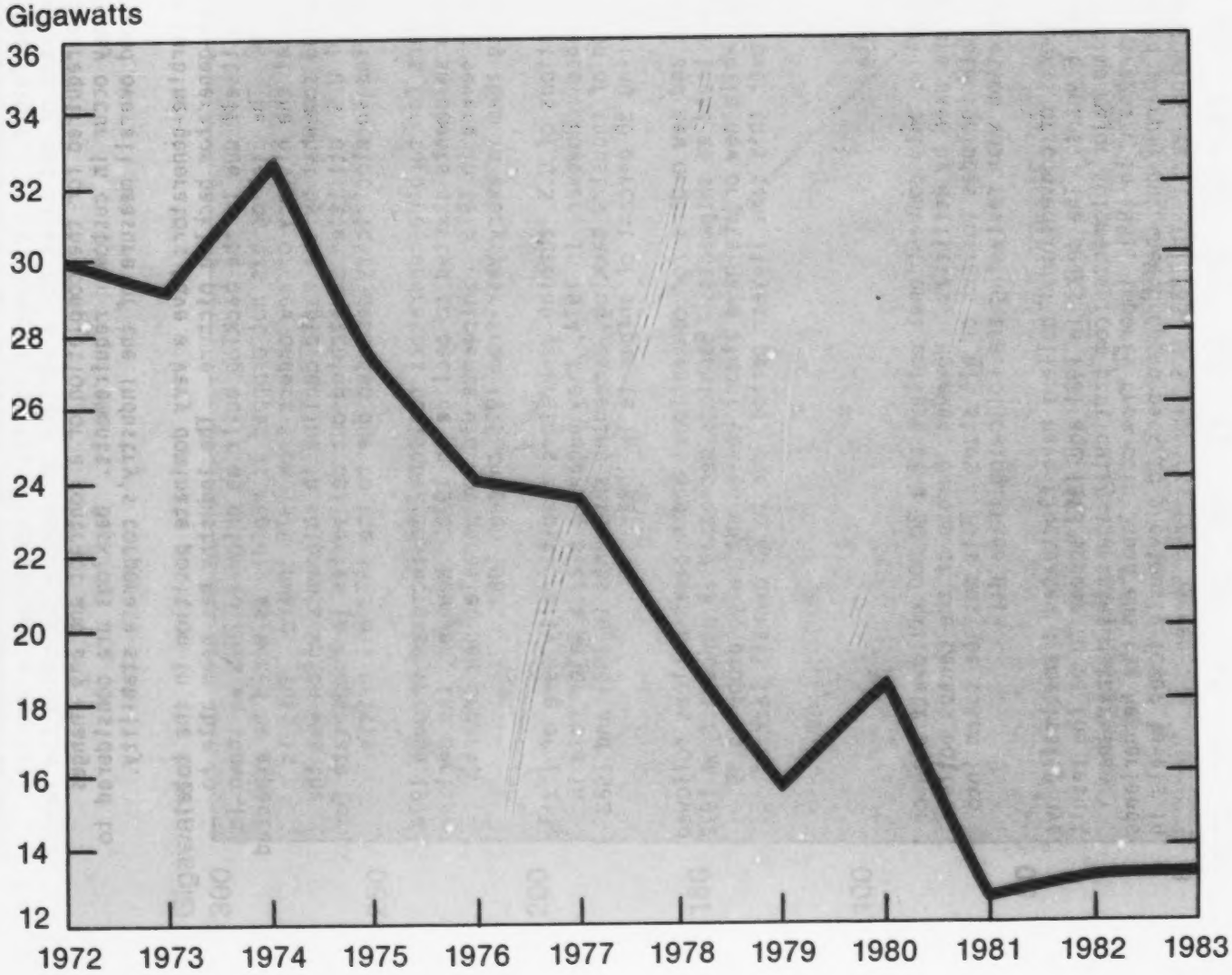


FIGURE 3

U.S. Shipments—Power Boilers

(Conventional and Nuclear)



Industry Backlogs and New Orders

Backlogs, or unfilled orders, are significant because the elapsed time between the placement of the order and its shipment ranges from 1-10 years. This fact enables a firm to project its revenues several years into the future. It is, however, difficult to project a specific annual rate of net sales for a variety of reasons including the length of time required for the completion of a contract and any changes which may occur in customer requirements. Backlogs are considered to be a good overall measure of the industry's corporate stability.

Steam turbine-generators have a very dominate position in the total turbine-generator backlog picture. The industry has been able to sustain itself due to the backlog built up prior to 1975 as shown in Figure 4. The backlog has not dropped as rapidly as would be expected looking at the history of new orders from 1975 onward. This is explained somewhat by the rapid decline in shipments which was the result of U.S. utilities stretching out deliveries to compensate for the decline in electricity demanded due to the 1973 oil crisis.

New orders for turbine-generators continued to increase through 1974 although shipments started to decline in 1973. However, the decline was most severe in 1975. Shipments did not parallel new orders, exceeding them in every year from 1975 through 1983.

Cancellations of U.S. turbine-generators traditionally were of little consequence. However, in 1974, they began to play a major role in reduction of industry backlog, exceeding shipments in 1981 and 1982 and equaling 50 percent of shipments in 1983.

Backlogs and new orders for conventional and nuclear boilers followed the same trend as shipments. Backlogs decreased 39 percent from 1972 to 1983 while new orders have almost ceased entirely, dropping 99 percent over this same 11-year period, due to an overall lack of demand.

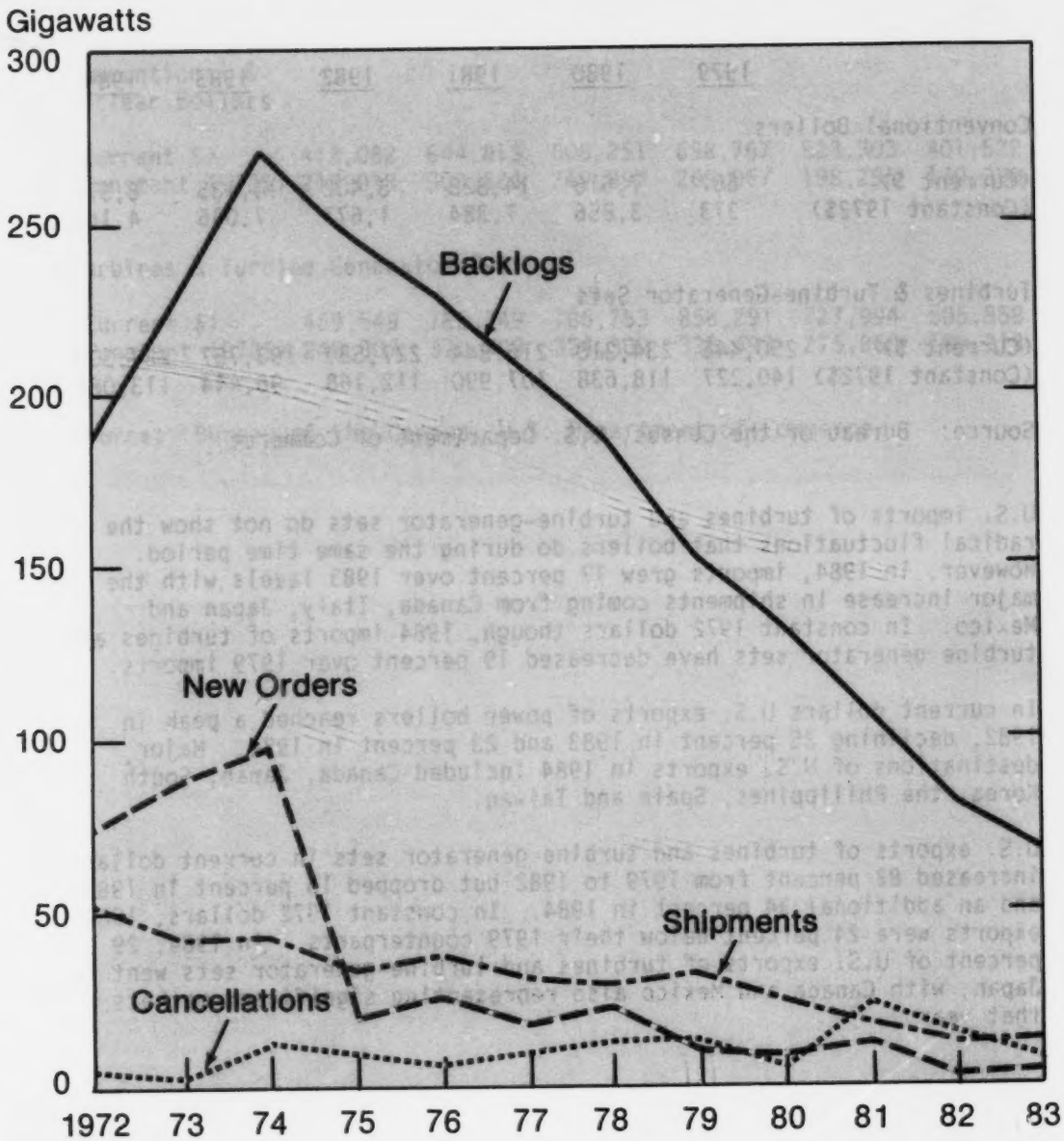
Trade Data

Customarily, only conventional boilers of a 30,000 killowatt size or larger are used by utilities. However, Bureau of the Census boiler import data includes boilers of <u>all</u> sizes. This must be taken into consideration when reviewing the following trade data.

U.S. imports of conventional boilers have fluctuated dramatically over the last 6 years. The peaks in 1981 and 1983 appear to be the result of one-time major shipments from particular countries rather than ongoing trends. In 1981, imports from both Japan and the Netherlands increased sharply but then dropped back to previously lower levels in the following years. In 1983, U.S. imports from Sweden

FIGURE 4

U.S. Turbine-Generators
Shipments, Backlogs, New Orders & Cancellations



were $8.3 million compared to $2,000 in 1982 and $31,000 in 1984. Major exporters of conventional boilers to the United States in 1984 were Canada and Denmark. Overall, U.S. imports of conventional boilers in constant dollar figures in 1984 were 11 times greater than those in 1979.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION
(Thousands of Dollars))

	1979	1980	1981	1982	1983	1984
Conventional Boilers						
(Current $)	667	7,616	14,828	3,402	14,135	8,370
(Constant 1972$)	373	3,856	7,384	1,677	7,036	4,164
Turbines & Turbine-Generator Sets						
(Current $)	250,445	234,310	216,844	227,589	193,757	227,309
(Constant 1972$)	140,227	118,638	107,990	112,168	96,444	113,089

Source: Bureau of the Census, U.S. Department of Commerce

U.S. imports of turbines and turbine-generator sets do not show the radical fluctuations that boilers do during the same time period. However, in 1984, imports grew 17 percent over 1983 levels with the major increase in shipments coming from Canada, Italy, Japan and Mexico. In constant 1972 dollars though, 1984 imports of turbines and turbine generator sets have decreased 19 percent over 1979 imports.

In current dollars U.S. exports of power boilers reached a peak in 1982, declining 25 percent in 1983 and 23 percent in 1984. Major destinations of U.S. exports in 1984 included Canada, Japan, South Korea, the Philippines, Spain and Taiwan.

U.S. exports of turbines and turbine generator sets in current dollars increased 82 percent from 1979 to 1982 but dropped 15 percent in 1983 and an additional 34 percent in 1984. In constant 1972 dollars, 1984 exports were 24 percent below their 1979 counterparts. In 1984, 29 percent of U.S. exports of turbines and turbine-generator sets went to Japan, with Canada and Mexico also representing significant markets that year.

Appendix A includes a listing of the products and trade classification codes used in compiling Tables 4 and 5.

TABLE 5

U.S. DOMESTIC EXPORTS
(Thousands of Dollars)

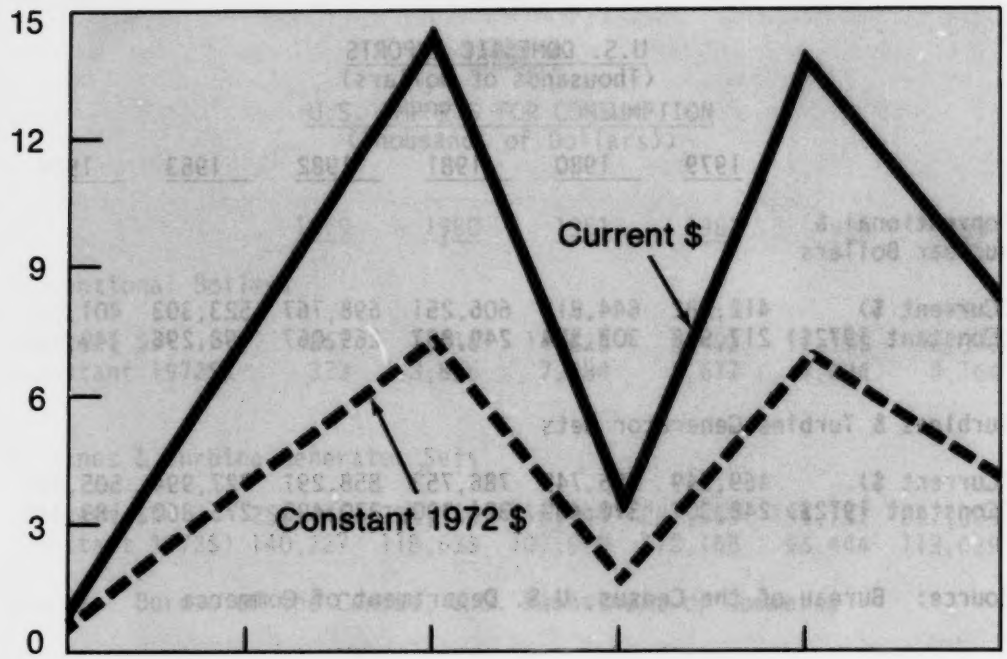
	1979	1980	1981	1982	1983	1984
Conventional & Nuclear Boilers						
(Current $)	412,082	644,813	606,251	698,767	523,303	401,522
(Constant 1972$)	217,918	303,584	249,897	269,067	198,296	149,990
Turbines & Turbine Generator Sets						
(Current $)	469,549	786,749	786,753	858,291	727,994	505,858
(Constant 1972$)	248,307	370,409	324,300	330,493	275,860	189,318

Source: Bureau of the Census, U.S. Department of Commerce

FIGURE 5

Power Generating Equipment Imports

(Conventional Boilers)



Turbines & Turbine Generator Sets

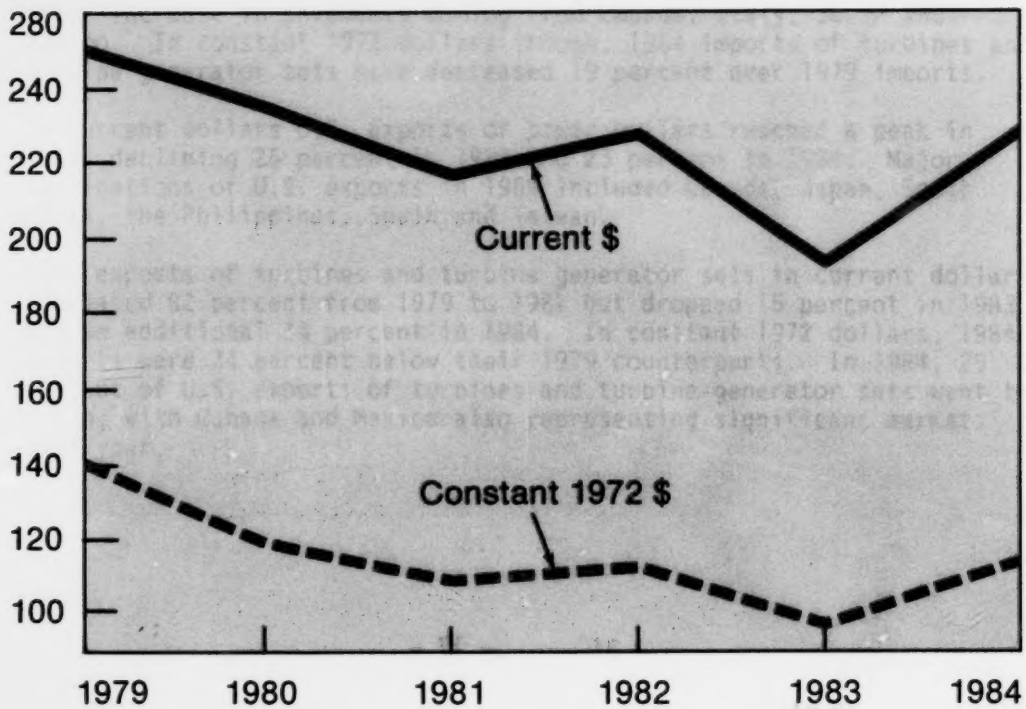
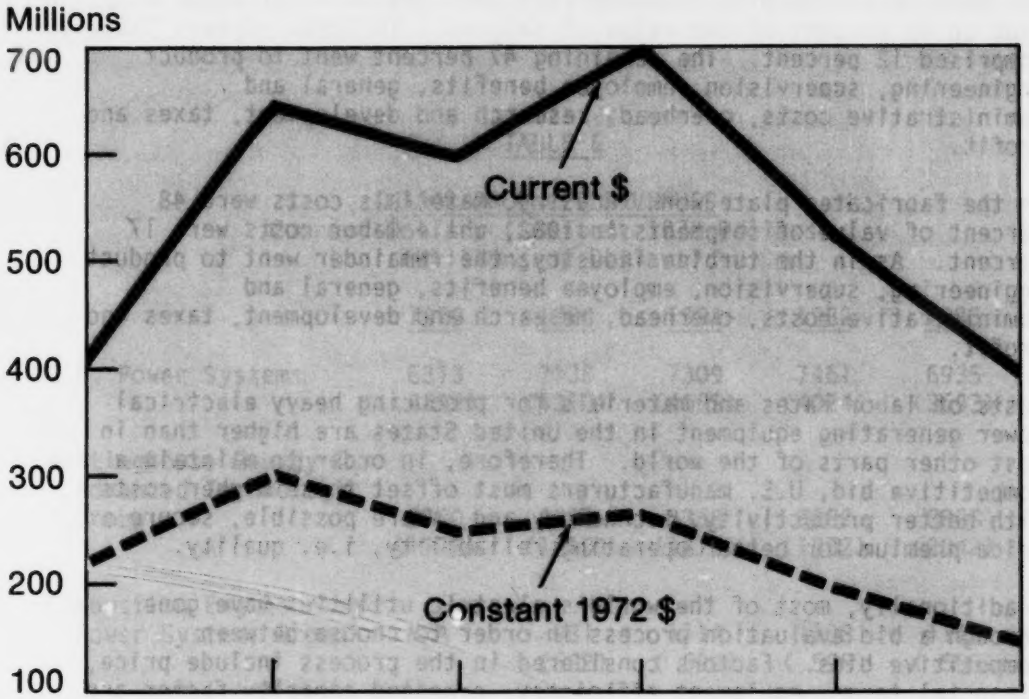


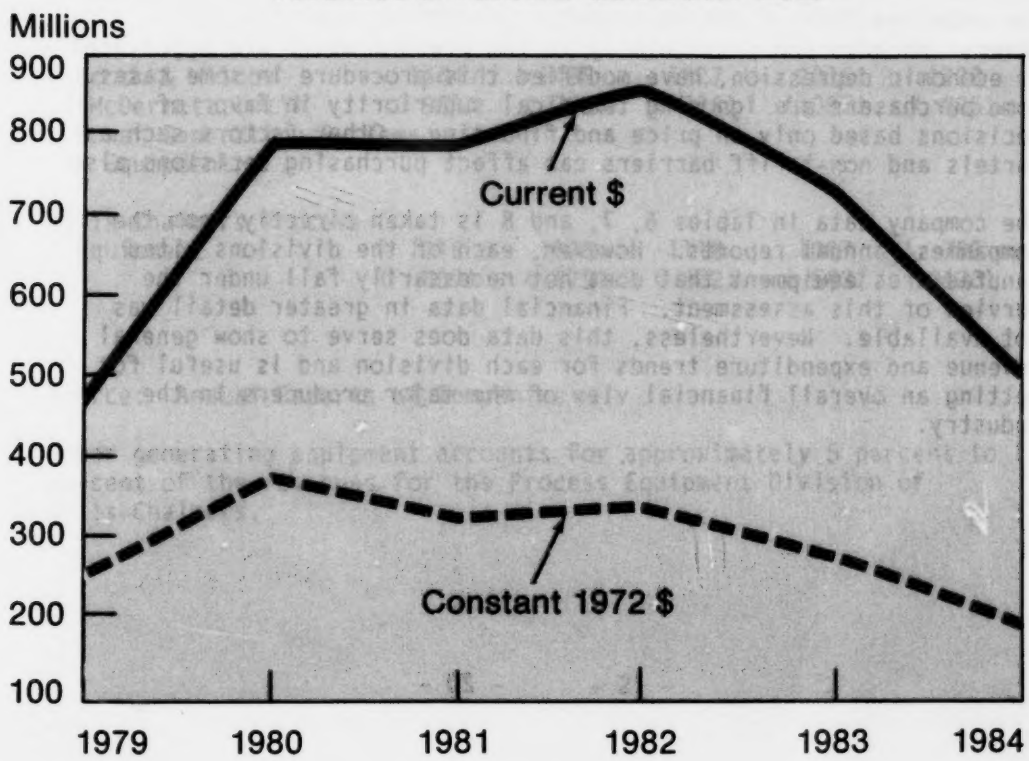
FIGURE 6

Power Generating Equipment Exports

Power Boilers



Turbines & Turbine Generator Sets



Industry Cost Factors

The major component of production costs in both industries under discussion is materials. The principal raw material is steel. In the turbine and turbine generator set industry, cost of materials made up 41 percent of the value of shipments in 1982. Direct labor comprised 12 percent. The remaining 47 percent went to product engineering, supervision, employee benefits, general and administrative costs, overhead, research and development, taxes and profit.

In the fabricated plate work industry, materials costs were 48 percent of value of shipments in 1982, while labor costs were 17 percent. As in the turbine industry, the remainder went to product engineering, supervision, employee benefits, general and administrative costs, overhead, research and development, taxes and profit.

Costs of labor rates and materials for producing heavy electrical power generating equipment in the United States are higher than in most other parts of the world. Therefore, in order to maintain a competitive bid, U.S. manufacturers must offset these higher costs with better productivity, technology and, where possible, secure a price premium for better operating reliability, i.e. quality.

Traditionally, most of the world's electric utilities have gone through a bid evaluation process in order to choose between competitive bids. Factors considered in the process include price, financial terms, equipment efficiency, expected capacity factor and reliability. The bid would usually be awarded to the supplier whose proposal resulted in the lowest cost for generating electricity over the expected life of the equipment. Conditions over the past several decades and particularly in the present which are aggravated by economic depression, have modified this procedure in some cases. Some purchasers are ignoring technical superiority in favor of decisions based only on price and financing. Other factors such as cartels and non-tariff barriers can affect purchasing decisions also.

The company data in Tables 6, 7, and 8 is taken directly from the companies' annual reports. However, each of the divisions cited manufactures equipment that does not necessarily fall under the purview of this assessment. Financial data in greater detail was not available. Nevertheless, this data does serve to show general revenue and expenditure trends for each division and is useful for getting an overall financial view of the major producers in the industry.

Industry Revenues

Revenues for each firm have fluctuated within the last 5 years. In general, the peak years for revenues were 1981 and 1982. However if price inflation is removed, "real" revenues for the most part have been declining since 1979.

TABLE 6

MAJOR PRODUCER REVENUES
Current Dollars (Constant 1972 Dollars)
(Millions of Dollars)

	1979	1980	1981	1982	1983
G.E. Power Systems	6313 (4145)	7138 (4310)	7309 (4065)	7461 (4024)	6935 (3693)
Westinghouse Energy & Advanced Technology Group	2700 (1773)	2998 (1810)	3368 (1873)	3582 (1932)	3835 (2042)
Combustion Engineering Power Systems Group	N/A	931 (562)	1114 (620)	1108 (598)	1113 (593)
Foster Wheeler Energy Equipment	660 (433)	595 (359)	646 (359)	678 (366)	552 (294)
Babcock & Wilcox (McDermott Int'l Power Generation Systems & Equipment)	1464 (961)	1488 (295)	1827 (1016)	2016 (1087)	1738 (925)
Allis-Chalmers Process Equipment	1016 (667)	1125 (679)	1118 (622)	1007 (543)	788 (420)

Source: Annual Reports of Companies

Power generating equipment accounts for approximately 5 percent to 13 percent of the revenues for the Process Equipment Division of Allis-Chalmers.

Industry Capital Expenditures

Although data is not available on specific capital expenditures to support the electric power generation operations of the major producers, Table 7 indicates the general level of expenditures in the company groups including such operations. The emphasis of such expenditures has been in the area of production capability and efficiency improvements.

Capital expenditures were between 1 and 6 percent of total sales for the major producers of power generating equipment during the 1981-1983 period. Much of this important expenditure was used to make manufacturers more cost efficient.

TABLE 7

CAPITAL EXPENDITURES
BY MAJOR PRODUCERS (% of Total Revenues)
(Millions of Dollars)

	1981	1982	1983
Foster Wheeler Energy Equipment	$ 14 (2%)	7 (1%)	4 (1%)
Combustion Engineering Power Systems Group	$ 19 (2%)	19 (2%)	14 (1%)
General Electric Power Systems	353 (5%)	323 (4%)	332 (5%)
Westinghouse Energy & Advanced Technology Group	184 (5%)	210 (6%)	224 (6%)
Babcock & Wilcox	37 (2%)	26 (1%)	25 (1%)
Allis-Chalmers Process Equipment	18 (2%)	22 (2%)	11 (1%)

Source: Annual Reports of Companies

Industry Research and Development

Research and development data is not available for the individual power systems divisions of Westinghouse, General Electric and Allis-Chalmers. Due to the considerable diversification of these companies, their total R&D data was excluded. However, industry spokesmen indicate that 3-5 percent of annual power systems division sales go towards research development for power generating equipment. Incremental improvements on existing products is the predominant R&D performed.

Due to the fact that R&D expenditures as a percentage of sales have remained relatively constant while sales revenues have been declining, the magnitude of R&D expenditures, in absolute terms, has also been declining.

TABLE 8

TOTAL CORPORATE R&D EXPENDITURES
AND PERCENTAGE OF TOTAL SALES
(Millions of Dollars)

	1981	1982	1983
Foster Wheeler Corporation	23 (1%)	21 (1%)	22 (1%)
Combustion Engineering, Inc.	47 (1%)	49 (1%)	59 (2%)
McDermott International, Inc.	N/A	106 (2%)	74 (2%)

Source: Annual Reports of Companies

III. U.S. ELECTRIC POWER GENERATING EQUIPMENT DEMAND

The demand for electric power generation equipment is determined by current and forecasted electricity consumption. Due to the requirements of their franchises and the desire to avoid the necessity of curtailing service to their customers, electric utilities make every effort to increase generating capacity to match forecasted load growth.

As a consequence of slowed demand growth for electricity worldwide, the demand for power generating equipment has also slowed, resulting in excess production capacity in the power generating equipment industry. This excess production capacity is expected to continue at least through 1990 although sources differ on how much excess capacity there will be.

TABLE 9

SUPPLY AND DEMAND FOR
HEAVY POWER GENERATING EQUIPMENT
(Annual Average in Gigawatts)

	Demonstrated Production Capacity	Estimated Market		Excess Gigawatts Capacity	
		1990	2000	1990	2000
U.S.	44	24	30	20	14
Japan & W. Europe	51	29	40	22	11
Developing Nations	0	30	49	(30)	(49)
Total	95	83	119	12	(24)

Source: United Nations Statistics, 1979

The most current U.N. statistics are from 1979 (see Table 9) and indicate a worldwide annual average excess capacity of 12 gigawatts in 1990. This data collection does not include gas turbines or cogeneration equipment. It also does not include the USSR or economically allied nations nor does it take into account the more recent equipment production capabilities developed by the People's Republic of China and certain developing nations. It does, however, include the PRC in the estimated market figures. While developed nation capacity is expected to exceed requirements by 12 gigawatts in 1990, according to the U.N. statistics by the year 2000 this excess will be depleted.

In contrast a current General Electric industry estimate shows a different picture. Table 10 (which includes gas turbines, cogeneration equipment, and developing nations production capacity) forecasts an excess capacity of between 62 and 74 gigawatts in 1990 in the steam turbine market. The PRC is not included.

TABLE 10

INDUSTRY ESTIMATED
SUPPLY AND DEMAND
FOR POWER GENERATING EQUIPMENT[1]
(Annual Average in Gigawatts)

	Demonstrated Production Capacity		Estimated Market - 1990		Excess Gigawatts Capacity - 1990	
	Steam	Gas	Steam	Gas	Steam	Gas
U.S.[2]	27	11.5	5	2	22	7
Canada	3	1	.4	--	3	1
Japan & W. Europe	74	20	17-21	9	52-56	10
Developing Nations	10	--	18-25	5-6	(7-14)	(5-6)
TOTAL	114	33	40-51	16-17	63-74	12-13

[1] Thermal utility and industrial generation, units 10 MW and larger.
[2] Includes cogeneration; net shipments, i.e. shipped units currently in storage and scheduled for installation between 1988 and 1993, have been deducted from additional needs.

The U.N. forecast did not foresee the changes in capacity and demand for power generating equipment that developed as a result of the domestic rise in the price of oil.

A significant difference between the U.N. forecast and the industry forecast is the demonstrated production capacity of the United States, Japan and Western Europe. In the United States, G.E. has considered as "closed" certain facilities that are presently not producing turbines (and in some cases are up for sale) but have major components necessary for production still in place and facilities that have been sold to be used for other purposes. The G.E. estimate also includes more recent increases in Japanese and Western European capabilities than does the 1979 U.N. data.

The estimated market for 1990 also varies between the two studies. The U.N. analysis foresees a larger turbine market in 1990, particularly in the U.S. than does the industry estimate. This reflects demand factors not foreseen in 1979.

Determinants of U.S. Electric Power Generating Equipment Demand

Heavy electric power generating equipment is purchased and operated by electric utilities. Most U.S. power is generated by private, investor-owned companies that account for 77 percent of the nation's generating capacity. However, the Federal Government has also established electric utilities in its effort to develop parts of the United States: examples are the Tennessee Valley and Bonneville Power Authorities. Federal installations operate approximately 10 percent of the nation's capacity. Municipalities established small electric utilities during the first third of this century. Most have since abandoned electricity generation because the economies of scale from newer, larger generating facilities rendered small municipal generating plants obsolete. Many of the remaining municipally owned electric utilities perform only the distribution function, purchasing their electricity from a larger bulk supplier. Cooperatives, many established and financed by the Rural Electric Administration, are becoming a more visible factor in total U.S. conventional steam generation (from less than 1 percent in 1963 to 5 percent in 1983).

The United States has the largest electricity generating system in the world. The size of this system has given U.S. equipment manufacturers the opportunity to lead the world in the design, development and production of electric power generating equipment. Continuous development of larger, more economical generating equipment allowed the real cost of electricity to decline until the 1970's.

At that time, competition between manufacturers was based on demonstrated and perceived reliability and economy of operation. As long as electric utilities were financially healthy, equipment manufacturers could expect to receive prices sufficient for vigorous research and development activity. Under these conditions, U.S. manufacturers established an industry that led the world in technology and productivity. Figure 7 demonstrates the U.S. lead in average turbine-generator capacity through 1979.

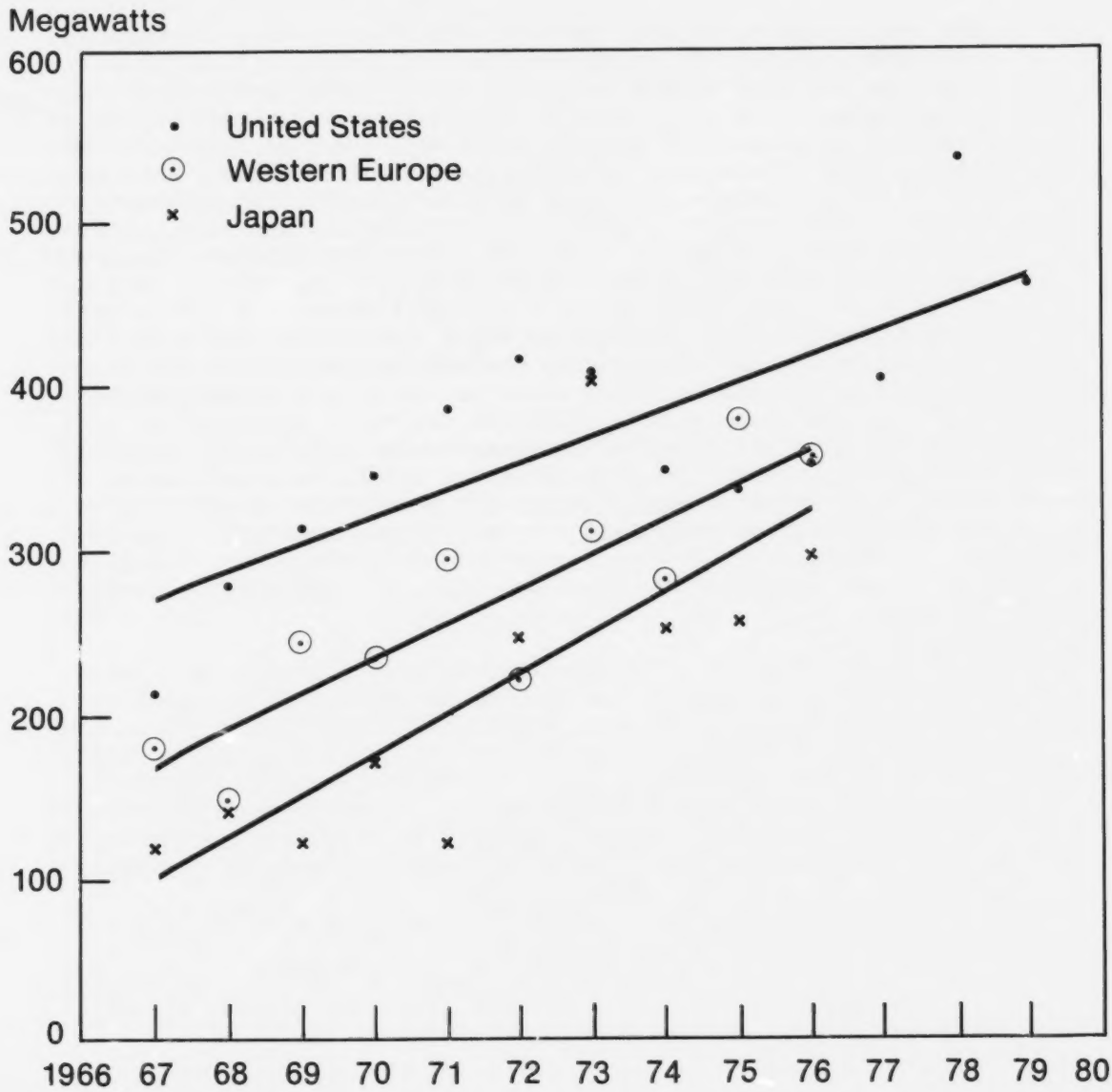
Prior to 1973, a large, perpetually increasing number of industrial, commercial and residential users found electricity more practical and economical than other energy sources. Utilities that failed to provide adequate generating capacity found themselves curtailing electricity use (usually major industrial users) and hurrying to acquire capacity (frequently oil-fired) to fill the gap. Because of these consequences and the requirements of their franchises, electric utilities made every effort to match expected load growth with programs for increased generating capacity. Utilities were financially sound and generally able to attract the capital funds for the most cost-efficient and reliable equipment available.

Utilities generally favored the most effective strategy for keeping costs down, which is to bring new base load power plants along a little earlier than needed to protect against underforecasting future demand. The electricity user gets lower rates under this strategy than the rates resulting from tardy addition to generating plants. When plants are late with respect to load growth, a utility must supply the larger loads with older, less efficient equipment or from facilities requiring expensive oil or natural gas fuel. Either alternative is more expensive for the electricity consumer than any base load plant slightly ahead of its need.

In 1973, energy prices skyrocketed and forced electricity price increases to follow. Electricity consumption dropped due to increased prices and resulting conservation efforts and economic recession. As a consequence, numerous major U.S. construction projects, which utilities had underway to meet previously forecasted increases in consumption, were cancelled at considerable expense. Others were too far along to cancel but were stretched out to delay the availability of now unnecessary additional capacity.

Figure 7

Average Turbine-Generator Capacity by Producing Area and Year



Electric utility rates are essentially state regulated. However, the Federal Energy Regulatory Commission (formerly Federal Power Commission) regulates the price of bulk power sales across state lines between utilities and grants licenses for hydrogenerating facilities. Regulatory policy and issues vary throughout the United States. Regulatory commissions allow utilities a rate of return on invested capital (often only on a "used and useful" basis as of time of operation) consistent with alternative investments of comparable risk. Utilities must file detailed financial and operational statements for regulatory and public review.

Until the 1970's the real cost of electricity per kilowatt hour declined. Through that period electrical consumption increased substantially as the nation proceeded with the mechanization of industry, agriculture and the home. Much of the cost of increased electricity use was offset by reduced generating cost passed on to customers by the utilities. Most utilities and commissions accomplished their functions smoothly and without major confrontation. Generally, the public felt well-served. However, since 1973, when electricity prices increased dramatically, electricity users have been angered and expressed their displeasure. As utility regulators are directly or indirectly chosen through the political process, many felt compelled to cushion the consumer shock by holding down utilities' allowed rates of return and earned income. Utility/regulatory confrontations became serious and common place.

Confrontations between electric utilities and regulatory bodies may continue for years. The cost of electricity from many recently completed plants has been driven up by high interest rates magnified by construction, public intervention, and regulatory delays.

The actual or expected cost of electricity from some new plants is so high that utilities are "phasing in" the charges. "Phasing in" is an accounting term whereby the utilities charge less for electricity than the rate allowed by the utilities commission. The main reason for doing this is to mitigate the shock of a sudden rate hike for consumers. "Phasing in" results in the utility deferring allowable earnings until depreciation allowances permit it to earn the allowable rate of return without charging higher rates. In the meantime, however, the utilities must borrow to compensate for the difference between the actual rate of return and the rate of return which has traditionally been allowed to the stockholders. However, the interest which the utility must pay on these borrowed funds is passed on to the consumer and not only results in rate increases anyway but overall results in the consumer paying more for electricity over a period of time than if the "phasing in" had never

taken place. The utility customer, the rate payer, bears the burden in either case and is additionally frustrated if he is paying for services not required. However, if the stockholder is forced to shoulder the burden through lower dividends, the utility's ability to raise capital funds at reasonable rates is severely crippled.

IV. U.S. INDUSTRY COMPETITIVENESS

U.S. Market Size

Total installed electricity generating capacity in the United States was 674 gigawatts (GW) at the end of 1984. This represents approximately 31 percent of the world's generating capacity. For the sake of comparison, total installed generating capacity of the world's major industrial countries in 1982 was as follows:

U.S.A.	666 GW
Japan	154 GW
F.R. Germany	85 GW
Canada	83 GW
U.K.	69 GW
France	74 GW
Italy	50 GW
Switzerland	14 GW

Figure 8 shows the production of electricity in the United States from 1949 to 1983. Since there is no practical way to store significant amounts of electricity, production and consumption curves are much the same. The chart presents two distinct patterns--one before and one following the 1973 oil embargo. Conservation efforts, coupled with economic recession have slowed growth from an annual average rate of 8 percent to 2.2 percent. Conventional steam systems continue to dominate with some changeover from oil to coal-fired units. Nuclear systems have enjoyed the greatest growth in the percentage of use since 1973.

From 1971 to 1982, average gross additions to U.S. capacity were 27 GW; consisting of 74 percent fossil, 19 percent nuclear and 7 percent other. However, in 1983, added capacity was only 15 GW's. While electric power consumption continued to grow at 2.2 percent a year, total energy consumption declined by 0.5 percent (see Figure 9). The forecasted annual market for the period 1985-1990 is 21-24 gigawatts.

The U.S. market for heavy electrical equipment has been depressed since the mid-1970's and is expected to continue in that state until sometime in the late 1980's or 1990's. Peak load and capacity data projected into the early 1990's by the North American Electric Reliability Council indicate favorable reserve ratios and therefore no threat of inadequate power supplies in the near future, provided all the generating capacity planned to be under construction is completed.

However, lead time for construction of a major plant ranges 7-10 years, so any generation additions necessary to meet future needs must be initiated well in advance.

FIGURE 8

U.S. Production of Electricity by the Electric Utility Industry by Type of Generation

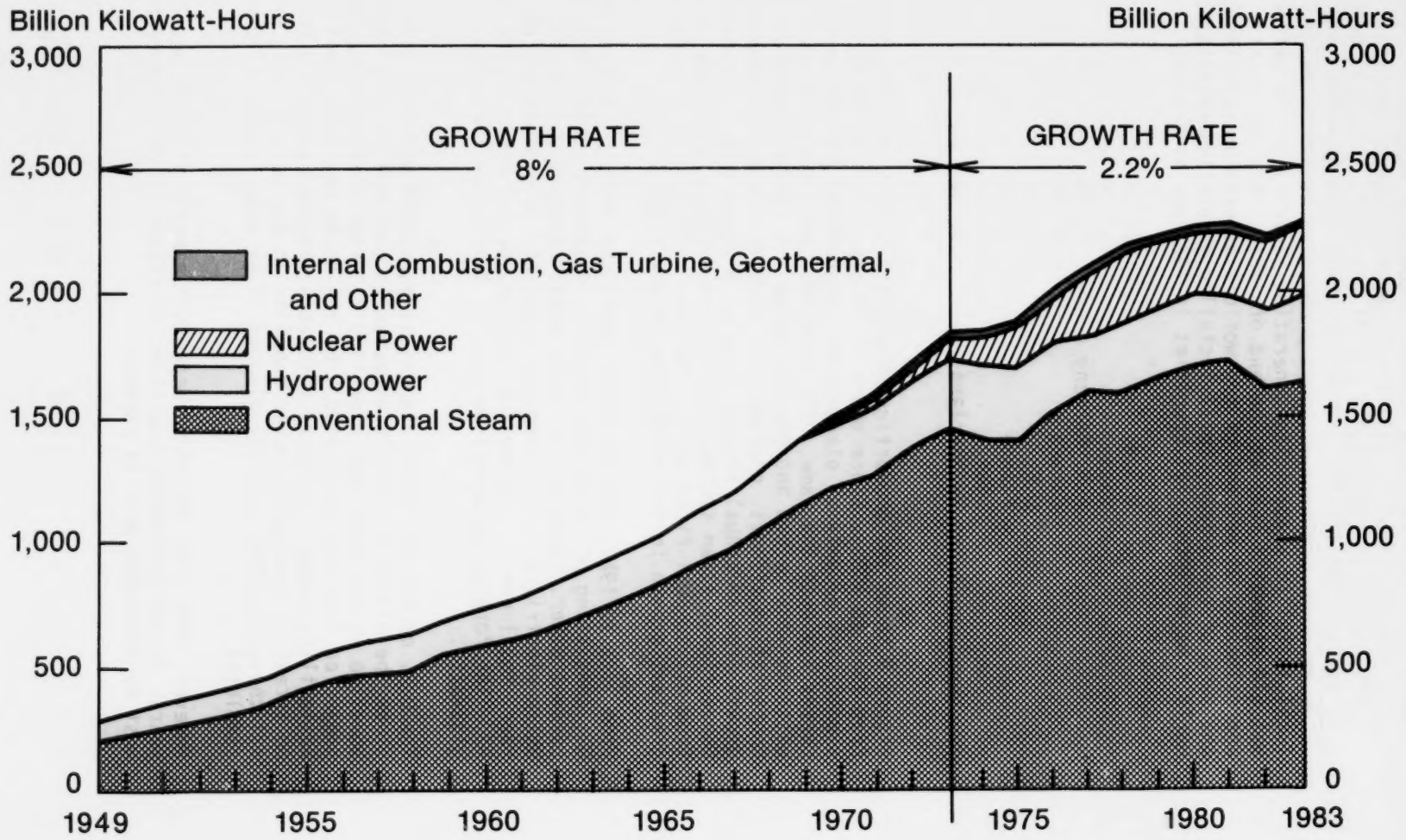
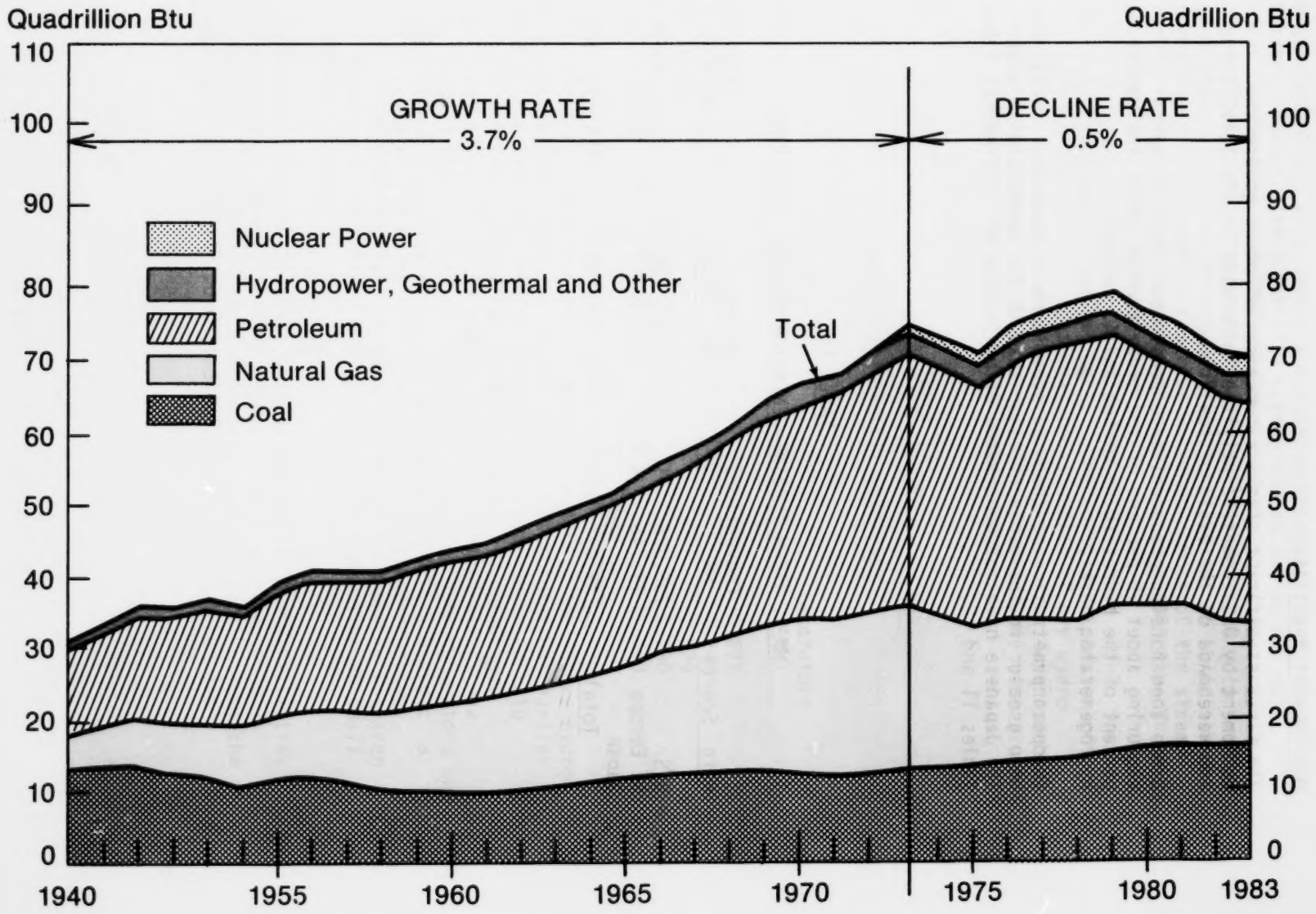


FIGURE 9

U.S. Consumption of Energy by Source



U.S. Market Penetration

The first significant offshore purchases of power generating equipment by U.S. domestic utilities were made in the late 1960's and were made on the basis of low prices.

Since then foreign producers have penetrated the U.S. market capturing about 10 percent of the steam turbine generator market, 45 percent of the hydroturbine market and 43 percent of the hydrogenerator market.

European penetration of the U.S. steam turbine generator market has been greater in the nuclear sector than in the conventional sector. The Japanese have not penetrated either sector of this market. See Tables 11 and 12.

TABLE 11

U.S. STEAM TURBINE-GENERATOR MARKET, 1970-1982

Mftg. Source	Conventional		Nuclear		Total	
	MW	%	MW	%	MW	%
U.S.	205,026	91.2	115,325	88.3	320,351	90.1
W. Europe	19,746	8.8	15,337	11.7	35,083	9.9
Japan	-	0	-	0	-	0
Total	224,772	100.0	130,662	100.0	355,434	100.0

Brown-Boveri had established a manufacturing facility in the United States. However, this facility is now closed and up for sale. Power Corporation - an Allis Chalmers-Siemens joint venture- is constructing a facility in Florida to build industrial motors and generators with plans to add additional facilities to build steam turbine-generators when the market warrants. Most of the steam turbine-generator sets imported from 1970 through 1982 came from the European facilities of Brown-Boveri.

The U.S. hydro market has two parts: One involves expansion of existing plants and the occasional construction of new hydro facilities; the second, pumped-storage projects. The Japanese have successfully entered this U.S. market for hydro-turbine generators. Table 12 shows participation by offshore producers.

TABLE 12

U.S. HYDRO MARKET, 1970-1982

Suppliers	Turbines 000 (HP)	%	Generators (MW)	%
Domestic	8,573	55	10,672	57
Japanese	7,027	45	4,242	23
W. Europe	-	-	1,629	9
Canada	-	-	2,100	11
	15,600	100	18,643	100

U.S. firms have a difference of opinion regarding the future hydro market suppliable from the United States. As pointed out earlier, General Electric has shifted production of hydrogenerators to Canada, and Westinghouse has stopped bidding hydrogenerator contracts altogether. By way of contrast, Siemens-Allis' new facility in Florida will be capable of producing hydrogenerators and Combustion Engineering announced the formation of C-E Neyrpic, a joint venture with Neyrpic of France to produce hydroturbines. Also, Allis-Chalmers has continued to invest in domestic research and development facilities and has developed a new line of small standardized units.

The Corps of Engineers, which designs and builds hydro facilities for quasi-government utilities, tends to be supportive of U.S. firms. In 1982, the Corps of Engineers, under directive from the Department of Defense, purchased only hydraulic turbines and

generators with 100 percent domestic content. However, in April 1983, the 100 percent requirement was withdrawn pending further investigation of national security justifications originally claimed. In July 1983, the Department of Defense issued specific procurement guidance for the Corps of Engineers when purchasing hydro turbines. This guidance included the requirements that the equipment designers have engineering departments located in either the United States or Canada and that certain parts be manufactured in either of these two countries. While this directive somewhat closed the gap opened by the April 1983 action, it did not totally eliminate foreign competition.

The Tennessee Valley Authority (T.V.A.) assumed a leadership role in the introduction of new equipment to the U.S. utility market. T.V.A. is a quasi-government, non-profit organization, free from federal taxes and without the state regulatory supervision imposed upon conventional electric utilities. T.V.A. encouraged foreign competitive equipment bids. As the result, it acquired a mix of foreign and domestically built equipment. All of the units - both U.S. and foreign built - were large, for their time, and introduced one or more "first of a kind" features. U.S. equipment has outperformed foreign equipment at T.V.A. (See Table 13.)

One event which affected the U.S. power generating equipment industry's sales to domestic utilities occurred during the early 1960's. The Justice Department successfully prosecuted firms in the electrical equipment industry for fixing prices and allocating markets. Firms were fined and executives served jail sentences. In 1962, the firms signed consent decrees covering most heavy electrical apparatus, agreeing not to eliminate or suppress competition or to allocate markets.

Following this prosecution and decree, an action was brought against Allis-Chalmers, General Electric and Westinghouse for bidding tactics thought to be illegal. However, the case was never tried. Allis-Chalmers, General Electric and Westinghouse signed another consent decree and later, in the mid-1970's, an addendum to the original agreement. Simply stated, these firms agreed:

1... not to discuss turbine-generator prices or features (that might relate to price) with other than an immediate purchaser;

2... not to discuss or share bid details; and

3... to terminate the preparation and circulation of price lists and announcements.

These stipulations hampered U.S. firms in the marketing of power generating equipment and put them at a disadvantage when competing with foreign firms who were not as limited in their business dealings.

Importation of foreign units has not always proved to be a total success. There are two important measures of power equipment performance: the availability factor and the capacity factor. The first factor presents a ratio of the time equipment is able to produce electricity to the total time in a given period. The capacity factor is a ratio of the power actually generated by a plant to the power it would generate if operating at full capacity for a given time period.

TABLE 13

U.S. vs. FOREIGN T.V.A. ELECTRIC POWER GENERATING EQUIPMENT PERFORMANCE
(Fossil Steam Systems Over 500 MW)

	U.S. T/G Sets (4008 MW)	Foreign T/G Sets (3700 MW)	Margin
Availability Factor	.834	.742	+12.4%
Plant Capacity Factor	.582	.443	+31.4%

A comparison of domestic and foreign equipment used at the T.V.A. plant appears in Table 13. Steam supply systems in these plants were produced in the United States. The favorable margins indicate a substantial and significant advantage to U.S. equipment. Capacity factors are included here because U.S. equipment has a reputation for being more productive than foreign equipment. Specifically, this suggests that U.S. units operate reliably at, and for short periods of time, above rated capacity, while foreign equipment may not. All T.V.A. units in Table 12 are base load units operating at maximum reliable output. Capacity factors are, therefore, considered a good measure of equipment productivity. These data support the U.S. industries' reputation for building higher productivity equipment.

T.V.A.'s experience suggested the need to view the performance of U.S. and foreign equipment throughout the United States. The North American Electric Reliability Council (NERC) collects and publishes equipment performance data for all U.S. electric utilities. NERC has supplied the data for Table 14.

This data reinforces the T.V.A. experience. Margins favoring U.S. equipment are not as large as at T.V.A., however, they remain both substantial and significant.

TABLE 14

U.S. vs. FOREIGN ELECTRIC POWER GENERATING EQUIPMENT PERFORMANCE (FOSSIL STEAM SYSTEMS)

Availability Factors

Size Range	U.S. (MW Capacity)	%	Foreign (MW Capacity)	%	Margin of U.S. Advantage
100-200	(70,376)	93.4	(777)	90.5	3.2
201-400	(75,460)	91.6	(2,898)	89.8	2.1
401-800	(150,240)	90.2	(16,319)	84.0	7.4
Over 800	(20,991)	89.4	(9,508)	85.6	4.4
TOTAL	(317,067)	91.3	(29,502)	85.3	7.0

Capacity Factors

100-200	(See Above)	55.9	(See Above)	35.5	57.5
201-400	(See Above)	55.4	(See Above)	44.5	24.5
401-800	(See Above)	55.6	(See Above)	42.5	30.8
Over 800	(See Above)	55.3	(See Above)	53.1	4.1
TOTAL	(See Above)	55.6	(See Above)	45.9	21.1

Foreign Market Size

Major offshore producers of heavy electrical power generating equipment are:

France	Compagnie General d'Electricite (includes Alsthom Atlantic and is nationalized)
Great Britan	General Electric Company Ltd. (not related to General Electric of the U.S.)
	NEI-Parsons
Italy	Ansaldo (part of Finnmechanica/IRI; government-owned)
Japan	Hitachi
	Fuji
	Mitsubishi
	Toshiba
	IHI
Sweden	ASEA
Switzerland	Brown-Boveri
	Sulzer Bros.
West Germany	Deutsche Babcock AG
	KWU-Siemens
	MAN-BBC-Mannheim

Table 15 provides a view of these suppliers' shares of total world installations during indicated periods. The erosion of the U.S. position is apparent. The gain has primarily been by Brown-Boveri.

TABLE 15

INSTALLATION OF TURBINE-GENERATORS
BY MANUFACTURING NATION
(GW and Market Share)

	1970-73	1974-77	1978-81	TOTAL 1970-81
U.S.	100.4 51.3%	91.3 47.9%	86.2 45.4%	278 48.2%
IEA				
Europe	63.4 32.5%	68.0 35.6%	78.1 41.1%	210 36.4%
Japan	31.7 16.2%	31.5 16.5%	25.7 13.5%	89 15.4%
TOTAL	196	191	190	577

Foreign Market Shares

Table 16 shows the export shares of free world manufacturing areas. Both this table and Table 15 show a declining trend in U.S. participation in the world market. They also illustrate the point that while U.S. firms are responsible for 48.2 percent of total world installations (domestic and foreign), the U.S. export share has only averaged around 12.5 percent since 1976. This means that the U.S. industry's primary market is its domestic market, which, as previously seen, is declining.

TABLE 16

TURBINE GENERATOR
EXPORTS/MARKET SHARE TRENDS
(Gigawatts)

Source	Annual Avg. Production 1955-75	1976-85	Exports (Annual Avg.) 1955-75	1976-85	Total Share of Exports 1955-75	1976-85
U.S.	13.1	21.7	1.0	1.4	21.3	12.5
IEA	12.8	18.6	3.7	9.8	78.7	87.5
Europe	(9.3)	(14.1)	(3.3)	(7.6)	(70.2)	(67.9)
Japan	(3.5)	(4.5)	(0.4)	(2.2)	(8.5)	(19.6)
TOTAL	25.9	40.3	4.7	11.2		

From 1970-1982, U.S. steam turbine-generator manufacturers exported an average of 11 percent of their total output. During the same time period, conventional boiler manufacturers exported 7 percent of their total production.

European and Japanese producers have sold some equipment to U.S. utilities, but historically these nations have been able to block significant intrusion by U.S. firms into their markets.

Western Europe (including the United Kingdom) looks inward for its heavy equipment. Producer countries buy national for nearly all major equipment. Countries that do not have full capability for products such as large steam turbine-generators usually have internal producers with close relationships to other European full capability producers. In these cases, the equipment is usually produced jointly, with the in-country partner supplying content to the extent of their capabilities. A similar situation has existed in Spain except that the out-of-country partners have been U.S., in many cases, working with their Spanish affiliates.

While there has been occasional inter-country competition in Europe on gas turbine and industrial steam turbine-generators, such competition is virtually non-existent on utility steam turbine-generators. Effective (and in some cases, formal) ties exist between government utilities and local equipment suppliers. In France and Italy, for example, both are government-owned.

The International Electrical Association (IEA) was formed by heavy power generating equipment producers in the 1920's. It is an export cartel (now comprised of European and Japanese firms) which provides the mechanism for allocating markets and setting prices. U.S. manufacturers were instructed by the Justice Department to withdraw from the IEA in the 1930's. During the 1960's, Japanese manufacturers were accepted as special members of the IEA. The existence of the IEA divides the world's producers into two groups. The United States' producers constitute one group and the world's remaining producers, who belong to the IEA, form the other group. As IEA agreements are not applicable to transactions in EEC countries, the U.S., or Switzerland, their impact is felt primarily in competition for the developing country markets. The agreements cover the participating members, their affiliates and licensees.

During the Tokyo round of GATT negotiations which concluded in 1979, the U.S. pressed unsuccessfully for inclusion of electric power generating equipment in the Government Procurement Code. This point is also an objective in the present round of GPC renegotiations. Success might offer a possible remedy to the exclusion of U.S. manufacturers from markets of many developed nations whose electric utilities are government-owned.

Developed Nations' Markets

U.S. participation in developed nations' markets is limited, for the most part, to Israel, Spain and Japan. Israel is not a producing nation and not a member of the IEA. Spain and Japan have both launched domestic nuclear power programs since 1955 by acquiring the necessary technology from the United States. Exports to those nations included "first of a kind" units and, later, only major components. Eventually, U.S. products were phased out in favor of domestic production.

Table 17 shows the United States is the largest importer of electrical plant equipment. However, the U.S. is only the fifth largest exporter to the world and to developed nations. The U.S. ranks only fourth in exports to the second largest importing nation, Canada, which buys primarily from the United Kingdom. Among the developed nations, the U.S. is the leading exporter in Japan and Israel.

TABLE 17

IMPORTERS AND EXPORTERS OF TOTAL ELECTRIC PLANTS
FOR THE PERIOD 1955 THROUGH 1983
(Gigawatts)

	Imports	Exporting Nations					
Importers (Developed Nations)		West Germany	Japan	Switzer-land	Great Britain	France	United States
United States	45.4	10.4	7.7	19.5	5.0	2.3	-
Canada	31.5	2.2	5.4	0.9	21.4	0.3	1.6
Australia	18.2	2.7	5.8	1.5	8.0	-	-
South Africa	18.2	4.9	1.6	3.1	4.4	4.4	-
Spain	16.9	3.0	3.0	3.9	1.9	1.4	3.9
Japan	12.0	0.7	-	-	0.1	-	11.0
Netherlands	11.3	5.3	-	-	3.1	-	-
Belgium	8.3	0.7	-	1.3	0.2	5.6	0.4
Denmark	6.2	1.4	-	4.5	-	-	-
Finland	5.1	2.3	-	0.1	0.2	-	-
New Zealand	5.0	1.4	0.3	-	2.3	-	-
Greece	4.7	0.7	0.3	0.2	-	2.2	0.5
Israel	3.0	0.3	-	-	0.9	-	1.8
Other	23.9	6.2	2.4	8.6	1.2	1.7	1.9
Subtotal	209.7	42.2	26.5	46.7	45.6	19.9	21.1
Importers (Developing Nations)							
Brazil	11.3	7.7	1.0	0.6	-	-	0.7
Mexico	9.6	0.8	7.4	0.2	-	0.7	0.6
India	9.5	1.7	0.6	0.1	0.8	0.4	1.4
Rep. of Korea	9.5	2.8	3.1	-	1.8	1.2	0.1
Iran	5.9	3.9	0.8	-	0.2	0.2	-
Argentina	5.1	2.3	0.8	0.5	0.6	-	-
Philippines	3.5	1.0	1.5	-	-	-	1.0
Thailand	2.6	0.4	2.0	-	-	-	0.2
Egypt	2.2	0.4	-	-	-	0.3	1.5
Kuwait	2.1	0.3	1.8	-	-	-	-
Singapore	2.0	-	1.6	-	0.4	-	-
Other	34.6	3.1	0.7	0.7	3.5	1.0	9.3
Subtotal	97.9	24.4	21.3	2.1	7.3	3.8	14.8
Total World	307.6	66.6	47.8	48.8	52.9	23.7	35.9
% of World	100	22	16	16	17	8	12

Note: Those data include power plants installed from January 1955 through those scheduled to be in service before December 1985.

Source: Based on data in U.N. Conference on Trade and Development's Study, "Trends in the Procurement of Electricity Generating Plant in Developing Countries" (TD/B/C/6) (AC.9/3). "A Business Assessment of Power Generation Technological Opportunities," Hayes/Hill Incorporated, Chicago, Illinois, February 1985.

Developing Nations' Markets

Open competition between foreign and U.S. producers is essentially limited to the markets of developing nations. In these markets, the U.S. competes primarily with IEA members.

As seen in Table 17, the United States is the third largest exporter to developing nations, following West Germany and Japan. Egypt is the only developing nation to which the United States is the largest single exporter.

Developing nations lack the technical, manufacturing and management capability to build their own power plants or they would do so. To most developing nations, a reliable and economic electricity supply is necessary for a future which may not include a domestic heavy electrical equipment industry. In such circumstances, a developing nation is interested in a turn-key supplier who can reliably care for its electric supply needs. In these instances, a developing nation can be expected to initially work with a small number of prospective power plant suppliers and from them select one.

European consortia and vertically integrated Japanese firms rise from a tradition of industry and government cooperation that gives them a decided edge in the preselection dialogue. U.S. firms find it difficult to speak with the kind of decisive single voice that is effective in this situation. After all, U.S. firms are competitors, adversaries, mediators or the reluctantly mediated as they operate domestically. It can be difficult for large U.S. firms to yield decision-making authority to a consortia in order to operate in a manner similar to their European and Japanese competitors. In addition, U.S. antitrust laws prohibit certain types of concerted activities, including some activities engaged in by IEA members.

Developing nations represent a broad range of electric power generating systems. Those just beginning may electrify individual population centers and have no grid connecting generating plants. Others may have population centers connected in a national grid but may not be providing service to small towns or rural establishments. Regardless of their present status, developing nations will most likely follow the pattern set by developed nations. Individual generating stations will be interconnected to provide a more reliable supply of electricity and generating equipment will increase in size to reduce the unit cost of electricity to users. Developing nations will find it economical to utilize the same large equipment employed by developed nations as their electrical systems approach comparable size. In some

developing nations, this has been the trend, however, many nations cannot accommodate the larger economical units. The United States is competitive in both small and large units and should therefore be able to supply developing nations regardless of the size of the unit required.

Previous U.S. export performance and future projections to developing nations are illustrated in Table 18.

TABLE 18

U.S. EXPORTS AND SHARES OF IMPORTS TO DEVELOPING NATIONS

	U.S. Exports to ($mil)			U.S. Share of Imports	Projected US Exports 1986
	1979	1983	% Change	1982	($mil)
Argentina	27.9	18.2	-35	15%	NPA
Brazil	73.3	31.7	-57	22	42.9*
Colombia	17.1	34.1	+99	27	115.2*
Ecuador	23.6	8.9	-62	34	3.8
Egypt	34.1	112.9	+231	28	178.7*
Guatemala	10.7	3.6	-67	26	40
Mexico	312.6	298.9	-6	45	212*
Nigeria	34.1	9.1	-73	11	277*
Panama	6.7	7.7	+15	51	31.4*
Venezuela	101.8	55.0	-46	44	109.8*
India	47.3	38.5	-19	10	NPA
Indonesia	24.1	48	+99	24	121.9*
Kuwait	15.1	10.4	-31	6	39.8*
Pakistan	7.1	13.7	+92	10	26.9*
Thailand	13.0	15.0	+15	14	27
UAE	24.4	14.5	-41	17	71.4

*--assumes no change in market share
NPA--No projection available
NOTE--These data include exports of all electrical power systems equipment--not only power boilers and turbines generator sets. The Egyptian and Indian markets currently require U.S. AID and/or grant funding for power generating equipment purchases.

In most cases, the projected U.S. exports in Table 18 are based on the assumption that U.S. market share will not change. On the negative side, foreign currency limits and an increasing number of "Buy National" policies in some countries could tend to decrease U.S. exports and shares. However, on the positive side, electric power generation systems are high priority for many of these same countries which also lack adequate domestic production to meet their needs.

Substantial markets currently exist in developing countries but the strength of the U.S. dollar and the limited availability of mixed credits or other low-rate, subsidized financing equivalent to that available to many offshore producers, is depressing U.S. export sales.

The People's Republic of China Market

The PRC's future electric power plans are best described in terms of six programs. The first is a domestic program involving Chinese technology and equipment with no foreign participation. The second is a program involving Western technology. This program is well underway and is targeted to create 10,000 megawatts of new fossil fuel fired generating capacity over a 5-year period. The third is less well defined. It involves Eastern Block (USSR and other centrally planned economy nations) technology. Credible sources estimate that the PRC has committed between 5,000 and 8,000 megawatts of fossil fuel fired capacity to Eastern Block nations for this program. The fourth program involves nuclear generating capacity of 10,000 megawatts to be accomplished by the year 2000. The fifth program has been delegated to individual provinces. An industry observer has identified nine twin 300 megawatts fossil fired plants in the program. The sixth program involves a hydropower proposal.

The Chinese domestic program involves fossil fired and hydro power plants of their own design and manufacture. They will be 300, 200 and 125 megawatt designs and will be as standard as local fuel and geography permit. The overall size of this program is not known.

The Western Block program subdivides into fossil fired plants of two sizes. The 300 megawatt size sub-program is committed to a consortium of EBASCO (Architect Engineer), Combustion Engineering (fossil boilers) and Westinghouse (turbine-generators). The Chinese program targets 70 percent off-shore procurement for the first turbine, 30 percent for the second, 20 percent for the third and 10 percent for the fourth and remaining units. Import content targets

for boilers are not known but would logically call for more domestic content. The 300 megawatt sub-program is paced at 1000 megawatts (3 1/3 plants) annually. Equipment deliveries from the United States for the first turbine generator sets are scheduled to be complete in December 1984.

The remainder of the Western program involves 600 megawatt fossil plants at the rate of 100 megawatts annually. No consortium has been chosen for the 600 megawatt sub-program. Competitors include two U.S. consortia (one involving General Electric and the other Westinghouse), Alsthom of France, Brown-Boveri of Switzerland, and Siemens' kilowatt unit of West Germany. Local content targets for this sub-program are the same as for the 300 megawatt units.

There is little more known regarding the Eastern Block Program. U.S. firms learned of it recently but have limited knowledge of the details. One can assume that the PRC will negotiate terms similar to those negotiated with the West.

The PRC's nuclear program is developing problems. The initial plant, Guangdong, has presented challenges for the Chinese, the French - leading contenders for the nuclear steam supply systems, and for Hong Kong - principal user of the electricity. Inability to resolve key economic issues has stressed the complex organization established for this project. Reorganization of the project appears imminent. The PRC's other two authorized nuclear projects may depend on cash flow from Guangdong and may be held up pending resolution of Guangdong issues.

U.S. nuclear equipment producers are unable to export to the PRC without the existence of a bilateral non-proliferation agreement. The U.S. Government requires all countries purchasing nuclear power equipment to sign a non-proliferation agreement. To date, there are several unresolved conditions preventing finalization of an agreement with the PRC. In the meantime however, other country suppliers are consumating agreements that may preclude future U.S. participation.

The fifth - Local Province program - is relatively new. All plants are to be turn-key projects. The first unit of this group has been awarded to Mitsubishi of Japan. Each provincial government is delegated the responsibility for negotiating the best possible terms for equipment financing, technology transfer, local content and financing for local content. Individual provinces are expected to execute this program rapidly.

Through the hydropower protocol Bonneville, TVA, the Bureau of Reclamation, the Corps of Engineers and some private companies have been active in feasibility studies. However, so far, contracts for projects have gone to the Japanese who offered favorable financing. Primarily the PRC will do the work domestically, and look for concessional financing for what they must buy from foreign suppliers.

The PRC is concerned with financing, level of technology and smoothness of transfer, and cooperation in establishing local production sources for the domestic content. U.S. consortia have won a portion of this market and are optimistic about winning more of it.

V. CURRENT AND FUTURE ISSUES

The Nuclear Dilemma

It is estimated that 20 percent of the U.S.'s electricity will be generated by nuclear plants by 1990 versus 13 percent in 1984. However, nuclear power faces technical, economic and political challenges throughout the world. The biggest technical challenges concern plant safety and efficiency. While the basic designs presently in use (the pressurized water reactor and the boiling water reactor) are expected to be the mainstay of the industry for many years, alternatives are being investigated. Most technoiogical advances are concerned with improving safety through variations on the cooling systems and the use of computerized monitoring and response systems and robots, and improving the economics of the industry.

The political challenges the nuclear power industry faces are also considerable. The main issue is the public risk associated with nuclear power, including both the danger from an accident and the perception of contribution to proliferation. Keeping public risk to a satisfactorily low level involves a necessary regulatory process but a process that is considered by many to be too time- and cost-consuming, and by many others to be too lenient and arbitrary.

At this point, the principal electrical energy alternatives are fossil and nuclear. Renewable resources and conservation have an important future role, however, nothing indicates the emergence of economic alternative energy sources that eliminate the need for fossil and nuclear power.[3]

Plant Standardization

One answer to the problem of high costs associated with the nuclear power industry is plant standardization. Custom-making a nuclear plant for the purchasing utility means that the Nuclear Regulatory Commission must review the plant from the time it is designed until the day it applies for an operating license, resulting in a very lengthy and costly process. Standardization, however, represents an

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[3]The International Trade Administration has completed a competitive assessment of the renewable energy industry. Readers may refer to this report for additional information on other energy developments.

alternative to this process. With standardization, all or part of a design is preapproved by the NRC and then replicated. The regulatory time is shortened considerably and construction costs are less. Modifications for safety or economic reasons are more easily adapted from one plant to another when they are of a standard design.

Standardization has its drawbacks though. Standardization does not allow for a great deal of regulatory flexibility. In addition, the nonuniformity of domestic nuclear power makes it difficult to determine which design should be the "standard." Also improvements in technology are temporarily foregone.

However, the view toward standardization is changing. In early January of 1985, the NRC issued a license for the Arizona Nuclear Power Projects Palo Verde-1, a 1,270 MW Combustion Engineering (C-E) System 80 standardized unit. This plant is the first in the United States to have part of its operating license preapproved by the NRC in a separate Final Design Authorization (FDA), which the NRC first issued in December 1983. A C-E spokesman said that this "confirmation of standardization" should increase opportunities overseas. In addition, the Chairman of the NRC announced in February of 1985 that the agency was submitting a legislative proposal to encourage the development and use of standardized nuclear power plants. It is hoped that continued development of standardized units will enhance U.S. competitiveness overseas in the nuclear power plant markets.

Three Mile Island

The Three Mile Island Two (TMI-II) incident continues to affect the nuclear power issue. Some may consider the incident a domestic problem, but it is of international interest. Several nations are participating in the clean up; others are simply standing by to see if and how we solve the technical, legal and political problems.

An equipment malfunction, complicated by improper operating procedures, caused severe damage to the TMI-II reactor core. Clean-up and disposition of the damaged core is estimated to cost $1 billion. TMI-II's operator, General Public Utilities (GPU), has provided $328 million, the insurance company $305 million, the States of New Jersey and Pennsylvania $41 million, the Edison Electric Institute $150 million, Babcock & Wilcox $21 million. In addition, the U.S. Department of Energy is providing $83 million for services, primarily the disposal of the damaged reactor core which is considered to be the responsibility of the U.S. Government. Japan is also contributing $18 million with the condition that twenty-two Japanese be allowed to observe the clean-up process.

The effects of TMI-II on nuclear power generating equipment manufacturers have been twofold. It is believed that the incident at TMI had a negative impact on the sales of future nuclear power plant projects. However, equipment manufacturers did benefit with increased sales in equipment required to upgrade existing facilities in order to meet the new safety requirements which came about as a result of the TMI-II incident.

The technical, legal and financial problems associated with TMI-II are substantial. Successful completion of the clean up project requires the cooperative efforts of utilities, equipment manufacturers, regulatory commissions, state and local governments and the Federal Government. Much can be learned from the condition of the TMI core and applied to future reactor designs.

Weapons Risks of Nuclear Power

The nuclear weapons proliferation threat is real and important. The limited relationship between nuclear power plants and weapons needs to be effectively communicated to and understood by the public.

Civil nuclear power plants alone do not pose a weapons threat. The proliferation problem comes with parts of the nuclear fuel cycle that are external to the power plant. Weapons material can be obtained by reprocessing spent nuclear fuel, from the enrichment process that precedes fuel fabrication, or from breeder reactors that are a source of fuel.

Nations launching civil nuclear programs must arrange for a supply of fuel over the expected life of their power plants. They must also arrange for the disposition of high-level waste from spent fuel and decide whether to use or discard the energy available from plutonium in the spent fuel.

As long as nations new to nuclear power utilize the facilities of developed nuclear nations for the supply and disposal of fuel materials, the proliferation threat is minimized. However, many nations now want to be self-sufficient with respect to nuclear energy and to provide their own enrichment, reprocessing, waste disposal and fuel creation (i.e., breeder reactor) capabilities. Every time another nation develops its own capabilities for key parts of the nuclear fuel cycle the chance for diversion and non-peaceful use of nuclear energy is increased.

The United States' best opportunity to influence other nations on non-proliferation issues comes when these nations first start their national nuclear programs. At this time, a nation decides to "make" or "buy" the materials and services that relate to the proliferation threat. The U.S. must respond positively to these nations' inquiries on fuel supply, waste disposition and other concerns in order to "sell" U.S. non-proliferation objectives and U.S. nuclear power plants.

The threat of proliferation is an additional barrier to U.S. exports of nuclear power generating equipment. Certain countries which represent possible markets for nuclear power plant equipment are not signers of the Nuclear Nonproliferation Treaty (NNPT) As a result, the U.S. Government maintains export controls with a presumption of license denial for nuclear-related goods and technology going to those countries. As an incentive to pursuade countries to sign nuclear non-proliferation agreements, the U.S. Government places varying degrees of limits on technology exported to non-signatory countries. While increasing the incentive by further limiting the level of technology a non-signatory country can import from the U.S. may encourage that country to sign, in the meantime it further restricts U.S. manufacturers' exports while competitor countries have accepted the importer's terms and their suppliers are not restricted.

Nuclear Fuel Cycle

The scientific community is addressing the environmental impact of nuclear and fossil energy use. There is evidence that nuclear power presents less of a threat to man and his environment than do fossil fuels. The environmental impact of the nuclear fuel cycle has been intensely studied and debated in preparation for nuclear waste disposal legislation passed by Congress. "Green House" and "Acid Rain" problems associated with fossil fuel consumption are also the subject of intense study. Facts collected thus far do not resolve all Green House and Acid Rain puzzles, but there is little doubt of the adverse impact of fossil fuel consumption. There is, however, considerable room for debate regarding the various solutions proposed for solving the problems.

There is obviously much work to be done by both the U.S. Government and the nuclear power industry. The Japanese have quietly joined France and Western Europe in their decisions to become independent of external assistance in the nuclear fuel cycle. These nations are or will become competitors of the U.S. in the world nuclear equipment market.

Continued safe development of nuclear power throughout the world requires government/industry cooperation within producer nations and an international political consensus on proliferation controls. Competitor nations have a longer tradition of government/industry cooperation. In some cases, government and industry are one.

Future success in economic and commercial nuclear competition hinges on the U.S.'s ability to convince others that it possesses the political skills, economic resources and national will to lead in completing the nuclear fuel cycle and developing a world consensus on nuclear safeguards.

Regulatory Issues

Electric utilities are one of the most regulated industry groups in this country. Most of their regulation comes from state regulatory authorities that approve utility rate changes, rates of return on investment and adequacy of service rendered. Federal regulation of U.S. electric utilities includes the pricing for bulk electricity transfers across state lines and the licensing of hydro generating facilities.

Nuclear power faces additional regulation. In addition to meeting state regulations, nuclear power projects must be federally licensed by the Nuclear Regulatory Commission. In order to limit the spread of nuclear weapons the United States Government requires export licenses for specific nuclear power plant equipment. The licensing of U.S. operating plants and issuing of export licenses are very complex and time-consuming processes which affect exports of U.S. nuclear power generating equipment.

State Regulatory Issues

States control the regulation of electric utilities in the U.S. Some state commissions are elected; others are filled by appointment. Many state commissions face politically and economically difficult decisions as this nation continues its adjustment to the impact of radical energy price changes launched by the 1973 oil embargo.

One of the most contentious issues facing utilities and regulatory commissions involves the utilization of plants and equipment of marginal need. The need for these plants and equipment is marginal because of the substantial lower rate of increase in expected electricity consumption. Many plants, both fossil and nuclear, were cancelled as the pattern of reduced load growth rates became recognized and accepted. Even though plants were cancelled, there exists a significant inventory of major equipment purchased for cancelled plants. Utility cost recovery for this equipment is an issue.

Utilities elected to complete some marginal plants because they were too far along to cancel. Completions sometimes pushed already high reserve ratios even higher. Inflation, high interest rates, and delays contributed to costs exceeding estimates by substantial margins. This problem exists with large power projects regardless of whether they are nuclear or fossil fired. Most of the recent problems between utilities and their state regulatory commissions involve the excess capacity problem and how the associated costs are to be allocated. Although some of the costs may be borne by the utilities through a lower return on investment, much of it will ultimately be reflected in higher prices for electricity. Both the existing excess capacity and the dampening effect of high prices on demand for electricity will limit domestic demand for power generating equipment in the near term.

Nuclear Regulations

The Nuclear Regulatory Commission (NRC), established in 1975, licenses the design and operation of nuclear power plants in the United States. It is charged with keeping the risk of public exposure to radioactivity as low as can be reasonably expected, while the industry's responsibility is to produce a safe, quality product at low cost.

The NRC has substantial impact on the design and construction of nuclear power plants. As well as approving initial licenses and designs, the NRC can order existing plants to be backfitted with improved safety systems. While these are actions desired by both industry and government, they can prove costly for the manufacturer or user and inhibit the standardization of nuclear power plants.

The U.S. introduced nuclear power to the world and has the world's largest nuclear power program. Consequently, most nations purchasing U.S. nuclear equipment have elected to follow U.S. practices in their regulation of nuclear power. Some nations have engaged U.S. consulting firms to perform the function of the NRC as other U.S. firms design, supply and construct nuclear power plants.

However, as foreign purchasers gain nuclear experience, they may find NRC regulations too costly and may abandon these standards to develop their own and consider looking elsewhere for nuclear power generating equipment. The possible loss of exports as well as the prospect of designing and building complex nuclear power generating equipment to differing standards could cause additional problems for U.S. manufacturers.

U.S. regulation in the form of export controls has also posed problems for U.S. manufacturers of nuclear power generating equipment. In the U.S. Government's role in international efforts to prevent the spread of nuclear weapons, it has used or threatened to use export licenses as leverage to win agreement with U.S. non-proliferation efforts. Affected and unaffected nations alike have at times reacted negatively to these U.S. tactics and question the reliability of U.S. supply. Stricter requirements by the U.S. Government for non-proliferation agreements permit competitors to negotiate equipment contracts without U.S. competition and may preclude future U.S. participation in affected country markets.

Future Technology

The United States enjoys a legacy of technological improvement in equipment used to generate its electricity. For the time being, there is little public attention focused on future electric power generation. Nevertheless, a review of emerging developments suggests that we can look forward to continuing improvement in the cost, cleanliness and reliability of our future electricity. Most of these developments will have significant impact on heavy electric power generating equipment. At the very least, most will affect the size of future power plants. Conditions prior to the early 1970's suggest that bigger might be more economical and hence, better. Some new developments suggest the possibility of smaller plants more closely matching load growth, located nearer load centers with additional savings in transmission losses and improving conditions for handling siting problems. U.S. Government agencies as well as private industry are engaged in continuing research and development. Following are brief reviews of some of the most promising developments.

Cogeneration

Cogeneration is an emerging market of major importance. Cogeneration involves the use of a single energy source to generate electricity and to perform one or more additional tasks with that

energy. The Public Utility Regulatory Policies Act (PURPA) defines a cogeneration facility as "a facility which produces electric energy and steam or forms of useful energy (such as heat) which are used for industrial, commercial, heating or cooling purposes." [4]

Typical cogeneration systems burn fossil fuels, produce electricity from steam and tap the process heat directly or to make hot air or water, chilled water, or other thermal energy products. Appropriate factories, ships, offshore drilling sites, oil refineries, hospitals, and other large institutions choosing to supply their own lighting, heating, and air conditioning energy are potential purchasers of cogeneration equipment. Two examples of present cogeneration use follow.

Paper mills use fuel to raise steam which is passed through a non-condensing steam turbine. The turbine in turn spins a generator which supplies electricity to power paper mill drive motors and fulfills other electrical requirements throughout the mill. Live steam from a non-condensing turbine is used to "cook" the paper pulp and then to dry it as it passes over large steam heated drums that are an integral part of the electrically driven paper mill.

Oil refineries offer cogeneration opportunities since steam heat is used to "crack" the crude oil into its refined components and electrically driven pumps move the crude and its products throughout the refining process. The steam can come from a non-condensing turbine which drives a generator supplying electricity for the many refinery pumps.

One section of PURPA requires electric utilities to pay "avoided" cost for independently cogenerated electricity. While "avoided" cost was not rigorously defined in the legislation it clearly lies between a utility's incremental additional per kilowatt fuel and operating expense at the low end and its full cost of generation at the high end. Utilities having ample generating capacity avoid only the cost of fuel and maintenance when they acquire electricity from a cogenerator. Utilities not having ample generating capacity can avoid building a new plant by purchasing cogenerated electricity. In such a case, avoided cost includes the capital costs associated with new generating facilities as well as fuel and maintenance costs.

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[4] PURPA became Public Law 95-617 in November 1978. It was amended in 1980 and again in 1984.

While the concept of avoided cost is clear, the identification of an exact figure for a specific contract is a complex task. Some cogenerators and utilities have successfully negotiated long term contracts, others have not. Differences are being argued before utility commissions. States have passed laws assigning specific values for "avoided cost", however, such laws are being tested in the courts. It will require time to arrive at a commonly accepted method for calculating "avoided cost." Until this is accomplished it will be difficult to evaluate the incentive for cogeneration created by PURPA and thus the potential affect on power generating equipment manufacturers.

Setting the problem of "avoided cost" aside, there are other complications in evaluating the impact of cogeneration. Support for cogeneration by utilities is important because the cost to the cogenerator is prohibitive if he has to install capacity for peak and maintenance periods. This means that the process will not work effectively unless the utility cooperates. At the present time, many U.S. electric utilities have the largest generating reserves in their history. As long as they have abundant capacity, utilities may follow a strategy that discourages cogeneration. By doing so they avoid the reliability and load imbalance problems that accompany cogeneration.

The economics of undertaking cogeneration in existing facilities are complicated by the cost of adapting existing land, buildings and equipment to energy conversion hardware not a part of the original facility. Cogeneration economics are best when they are part of a new facility designed with cogeneration in mind. However, cogeneration facilities have also been successful when installed adjacent to existing facilities. It follows then that cogeneration application will increase as the nation approaches full utilization of existing plants and requires new facilities in order to expand production.

Presently, cogeneration is responsible for 7 percent of the electricity produced in the U.S., up from 5 percent in 1983 and 3 percent in 1981. It is projected that by 2000, cogeneration will produce 15 percent of electricity. According to a 1983 Frost and Sullivan study, annual spending for cogeneration equipment could reach $2 billion by 1985 and $3 billion by 1990. By 2000, total cogeneration equipment sales could reach $60 billion, with an annual sales volume of $5 billion.

New technology is making cogeneration equipment less expensive and more efficient. New systems are smaller and less customized in commercial, small power plants (less than 1000 kilowatts).

Generally speaking, cogeneration involves more gas turbines to achieve higher combustion temperatures, more small waste heat boilers and steam turbines to utilize the energy from gas turbine exhaust, and smaller generators to match these turbines. U.S. manufacturers lead in the production of gas and steam turbines, waste heat boilers and generators. When new production facilities are required and regardless of whether those facilities are owned and operated by new facility owners, delegated to a utility, or owned and operated by a third party, U.S. manufacturers are in a good position to supply the required cogeneration equipment.

New Outlook-Conventional Equipment

The radical change in energy prices and ensuing economic adjustments have forced reexamination of equipment and consumption practices in the United States.

Until 1973, attention was focused on expanding the nation's generating capacity and improving its efficiency. Older equipment was generally kept in place and operated intermittently to meet swing or peak loads. Loss in reliability was met by holding on to older equipment. Even at reduced efficiency, the older (fully depreciated) equipment is more economical than new for low load factor use. Occasionally, utilities return old equipment to its manufacturer for rebuilding.

Turbines can be rebuilt with new, more efficient blading at a fraction of the cost of new units; this is especially true for steam and hydro units. Much the same is true of generators. They can be rewound with new coils and improved insulation and cooling systems. A significant part of meeting future utility generation needs may come from rebuilding and upgrading older underutilized equipment which would have formerly been retired and replaced by new units.

Utilities and manufacturers are currently undertaking studies of this approach. As with turbine generators, many of the elements of a power plant are not "wearing parts" and could operate for many more years at high economic efficiency after appropriate refurbishing.

Smaller Plants

Prior to the 1973 disruption in energy prices, the utility industry found it economical to build very large power plants. The economical nuclear plant size was most often 1300 megawatts and several large utilities found 1300 megawatts the best size for coal-fired units. High interest rates and extended construction schedules introduced new and significant cost variables to the process of selecting best plant size. With these new cost factors, some find that coal-fired units in the 200-500 megawatt size range prove economical. They offer good economy to scale and can be built in significantly less time than larger fossil or nuclear plants. Smaller plants allow a utility to reduce underutilized capacity which sometimes results from the addition of larger blocks of capacity. This possible trend towards smaller plants could also result in a reversal of the current trend of municipalities only reselling power. The municipalities could return to generating power as they have in the past.

Gas Turbines

The gas turbine is relatively new to the utility industry. The first units were installed in the early 1950's. In the mid-1960's they gained wide acceptance for peak load service. These peaking installations were of both the heavy duty and aircraft engine derivative types. The 1965 Northeast blackout accelerated this acceptance. Because the gas turbine requires oil or natural gas for fuel, utilities lost interest at the time of the OPEC embargo. Since utilities do not need new capacity at the present time, there is still little incentive to develop turbines that operate on coal or other less expensive fuels. There has been experimental work on high temperature gas turbines and low cost, high efficiency heat exchangers for both combined cycle applications and recuperation capabilities which would make them more efficient. Also, integrated coal gasification combined cycle thermal plants under study offer an additional use for gas turbines. The aircraft derivative gas turbine is best operating in simple cycle applications. The heavy-duty industrial gas turbine, in contrast to aircraft derivative designs, is more compatible with combined cycle operations. Platform applications represent a specialized market for aircraft derivative units.

The gas turbine can be developed to operate at higher temperatures; hence more efficiently. Until 1980, the Department of Energy sponsored and partially funded a program for high temperature gas turbine development. Some work continues in the private sector. The Japanese, in the late 1970's, formed a joint industry-government development program similar to that of the United States. Reports indicate favorable progress to date.

Pumped Storage System

The pumped-storage system employs equipment in an innovative system designed to enhance the economic efficiency of power generating systems. Economic efficiency is improved by employing underutilized thermal generating capacity during off peak periods to pump large volumes of water into elevated reservoirs. The energy thus stored is run back through the same physical equipment at peak load periods to produce electricity in tandem with fully loaded thermal facilities. This system allows higher utilization of the thermal plant capital investment and provides the consumer with peak load power at a cost considerably below alternatives.

Combined Cycle

An example of an improved system is found in the combined cycle unit. This development uses established equipment in a new system package to reduce the cost of electricity. Conventional power plants are capable of turning about 33 percent of their energy source into electricity. The combined gas/steam turbine cycle improves that performance to 44 percent. Unfortunately, the combined cycle was introduced in the United States just before the 1973 oil embargo greatly increased the price of required petroleum or natural gas fuels.

Supercooled Generators

The size of a turbine-driven generator is governed by the amount of heat that it must dissipate in order to keep insulation and windings sound. While large generators run at efficiencies of about 99 percent, the 1 percent loss within a million kilowatt generator represents a major heat dissipation problem. Much of the loss comes from resistance to the flow of electricity in generator windings. Engineers have long known that some materials offer little or no resistance to the flow of electricity when cooled to near absolute zero. Electrical manufacturers have produced proof-of-principal, supercooled generators. The supercooled generator promises to be about one-third the size of its conventional counterpart allowing more complete factory assembly and greatly simplified shipping and erection. The expected lower initial cost and improved operating efficiency would pay dividends throughout the life of the unit. However, control problems of the turbine generator set must be considered because of the very low inertia of the superconducting generator rotor. In addition, the long-term reliability of the complex construction and cooling system has yet to be demonstrated.

Fluidized Bed Combustion

Utilities must use the best available technology to remove pollutants from the products of combustion before discharge to the atmosphere. Recently built coal-fired plants include scrubbers that spray a wet limestone slurry into exhaust gases in order to remove the oxides of sulfur and nitrogen. Scrubbing requires a substantial amount of electrical energy and reduces the net output of a power plant. Additionally, the resultant sludge presents a major disposal problem. Initially, the problem was met with large settling ponds which permitted the evaporation of moisture and subsequent removal of sludge for land fill. The large acreage required for sediment ponds and absence of desirable land fill area made this mode of disposition impractical. Utilities soon elected to add chemical facilities to process the sludge into marketable by-products thus reducing the disposition problem.

More recently, dry scrubber systems have been developed. Dry scrubbers work similarly to those spraying the wet limestone slurry but the resulting byproduct is gypsum which is a more useable substance than the resultant sludge given off by the wet limestone slurry scrubber.

Utilities may find an answer to remaining scrubber problems in fluidized bed combustion. In this system, combustion takes place in a bed of fuel and finely ground limestone. The bed is supported on a column of air which also provides oxygen for combustion. Combustion temperatures are lower in a fluidized bed, thus, eliminating the formation of undesirable oxides of nitrogen. Sulfur is captured in the fluidized bed by limestone. The two combine to form gypsum which is removed in a dry, easily handled form and has commercial value.

Several small fluidized bed boilers are in operation today. Experience indicates that this process can handle a wide range of fuels efficiently without the electrical losses imposed by scrubbers. TVA will be the site of an electric utility-sized fluidized bed boiler. A major boiler manufacturer will soon be selected to join this demonstration project. Assuming reasonable operating experience, manufacturers and plant designers can turn their attention to overall designs that make maximum economical use of this principle.

Following closely behind this development will come the pressurized fluidized bed combustor. It offers many of the advantages of the (atmospheric) fluidized bed, plus the possibility of a physically smaller system since it is pressurized. This system may be useful as a coal gasifier for the production of economical gas turbine fuel.

Integrated Coal Gasification Combined Cycle

Other systems innovations are under development which may have major beneficial impact on the cost of future electricity. One is the Integrated Coal Gasification Combined Cycle (IGCC) thermal plant.

This plant integrates an established coal gasification system with a gas/steam turbine combined cycle system. By integrating these systems, use can be made of heat normally wasted in the coal gasification process, and undesirable products of the gasification process can be removed cheaply so that coal, in effect, becomes the gas turbine fuel. Participants in the IGCC demonstration project suggest that this system can be produced in cost-efficient small modules that can grow in close parallel to increasing demand. The system meets this nation's most stringent air pollution standards comfortably and could play a major role in future utility expansion. The reduced construction cycle and smaller individual plant sizes result in lower finance charges during construction. A shorter construction cycle also reduces the adverse impact of errors in forecasting future electricity use.

Transmission Systems

The development of high voltage D.C. transmission lines may have significant impact on future purchase of heavy electric power generating equipment. The patterns of electrical consumption result in under utilization of some generating capacity. Years ago, utilities agreed to interconnect so that they could pool generating capacity, share load and reduce costs by handling loads with the most efficient equipment. Pools are limited in part by transmission losses since they offset the savings from more efficient generation. High-voltage DC Transmission permits blocks of power to be sent longer distances economically. This technology introduces the possibility of larger pools, higher load factors and the deferral of new equipment purchases.

Magnetohydrodynamics (MHD) Plants

Magnetohydrodynamics (MHD) plants involve a technology whereby thermal energy is converted directly into electricity. This process has the potential to extract more power per ton of coal than existing conversion systems. It also reduces significantly the emission of sulfur dioxide and other pollutants into the atmosphere.

The process involves mixing coal dust with potassium carbonate seed and then burning the mixture explosively in preheated air. The resulting superhot plasma is forced through a channel, which is surrounded by a powerful magnetic field, generating direct current. The hot gases, which are discharged from the channel, drive a conventional steam turbine-generator.

Any fossil fuel can be used to heat the gas, however, coal is being used as it is the United States' most abundant energy source. Potentially, up to 50 percent more power can be produced from a ton of coal with the MHD process than at a conventional steam plant.

The Department of Energy has allocated $31 million in its fiscal 1985 budget for a proposed 5-year R&D program to examine the feasibility of commercial MHD power plants. Three companies are developing MHD components: TRW (the primary combustor), Avco (the MHD channel), and Babcock and Wilcox (the modified down-stream steam boiler). The Department of Energy has requested that these companies and interested utilities participate in funding the program by contributing facilities, labor, materials or fuel.[5]

Advanced Nuclear Power Systems

Although nuclear power is relatively new to electric power generation, the technology is ready for "second generation" designs to enhance economics.

Control systems are greatly improved since the introduction of nuclear power. Nuclear power designs must provide maximum protection to the public. Today's nuclear plants are shut down when any condition exists that could threaten public safety. Experience indicates that many shut downs occur because of events that turn out to be insignificant. Microelectronics, sophisticated remote sensing devices and fibre optics are new and proven technologies that can safely eliminate many unneeded shutdowns.

The U.S. Position in New Technologies

A technological edge will be an important factor for firms competing in the future market of limited demand.

Advances in technology are driven by two forces. Equipment manufacturers propose innovations that lead to lower cost equipment or utilities identify the need for equipment advances. In either case, the proposed change is translated into an appropriate program involving proof-of-principal models, development of demonstration facilities, followed by commercialization.

The basic focus of many research and development projects undertaken by equipment manufacturers is to improve combustion performance of the boiler and to upgrade/enhance the long-term operation of the steam turbine generator.[6] Table 19 lists examples of representative projects in these areas.

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[5] "Magnets Draw Clean Power From Coal", High Technology, January 1985.

[6] Source: "A Business Assessment of Power Generation Technological Opportunities: Stage 1", Hayes/Hill Incorporated, Chicago, Illinois, under contract to the U.S. Department of Commerce; September 1984.

TABLE 19

REPRESENTATIVE UNITED STATES FOSSIL FUEL POWER GENERATION PLANT RESEARCH AND DEVELOPMENT PRIORITIES

Overall R&D Goal	Approach
Reduce boiler emissions (Acid Rain) of SOX and NOX	Atmospheric fluidized bed combustion Deep cleaning of coal Emission clean-up Scrubbers Electron beams Improved combustion controls Higher pressures through advanced materials
Enhance steam turbine availability and reliability	Improved turbine blade performance through design, materials, etc. Key part upgrade/replacement On-line diagnostics Sensors Computer models/artificial intelligence.

Source: "A Business Assessment of Power Generation Technological Opportunities: Stage 1", Hayes/Hill Incorporated, Chicago, Illinois, under contract to the U.S. Department of Commerce; September 1984.

In the United States, as in other producer nations, electric utility demand for new equipment of any type is currently limited. Consequently their demand for innovative equipment designs is limited. In the United States two major developments continue that are "electric utility" driven: the Integrated Coal Classification Combined Cycle demonstration facility brought on line in 1984 at Dagnet, California and the utility sized fluidized bed boiler being developed for installation at TVA's Shawnee plant at Peducah, Kentucky. Both efforts are aimed at converting coal to electricity more efficiently and with reduced environmental impact. Comparable efforts are not underway in other nations and the U.S. clearly leads in these technologies.

Two major technology developments are underway that involve the Japanese. One involves advanced nuclear reactor systems and the other high temperature gas turbines.

General Electric and Westinghouse negotiated agreements with Japan for the joint development of advanced nuclear reactor systems. General Electric and its licensees will develop a new generation of boiling water reactors and Westinghouse, with its licensees, will develop the next generation of pressurized water reactors. The agreements provide for equal access to new designs and full participation in the construction, start-up and initial operating experience from early plants.

A high temperature gas turbine development program was undertaken in Japan in 1977. Many consider General Electric the world's leader in the application of gas turbines to electric power generation. Development of aircraft gas turbines is continuous at General Electric and it transfers appropriate technical advances to its industrial turbine line. There is every indication that General Electric will continue its development of industrial gas turbines and that it will not fall behind the Japanese or others.

Current Foster Wheeler R&D includes the arch-fired boiler that is able to burn low volatile fuels (usually difficult to burn). Combustion Engineering is involved in the development of fluidized bed combustion and the development of coal slurry fuels.

Significant technology advances in electric power generation equipment or its application are practically impossible to make in secrecy. From their early beginnings, advances require cooperation and information exchange between manufacturer and sponsor utility. Additionally, one or more manufacturers's suppliers are usually involved in significant efforts. It is common practice for involved personnel to discuss current projects at professional association meetings or in the normal course of doing business. Through these routine channels, U.S. manufacturers and utilities maintain knowledge of equipment developments throughout the world. While today's efforts are depressed by poor markets, U.S. producers usually learn quickly of major competitor nation efforts, evaluate those efforts, and make an appropriate response.

The foregoing has discussed the U.S. leadership role in electric utility equipment technology. U.S. manufacturing technology is probably as important as the design technology of the equipment produced. Both General Electric and Westinghouse continue major programs for improving manufacturing and equipment servicing productivity. Costly new computer aided design and computer aided manufacturing systems are used by both firms as well as newly purchased machining centers, remotely controlled, and robot devices. Funds for these manufacturing developments are internally generated from new product sales and equipment servicing contracts even though the electric utility market for new equipment is depressed.

The U.S. Government Role in the Research and Development of New Technologies

The U.S. Government has an important and valid role in supporting research and development (R&D) in experimental electric power generation technology. Successful results may eventually be translated into competitive advantage by the U.S. private sector.

Individual firms often find large-scale experimental R&D too costly and uncertain as an investment alternative. The private sector concentrates primarily on short-term commercial applications with good profit prospects. These applied R&D projects may include joint ventures with foreign firms such as current U.S. private sector programs in Japan.

U.S. Government electric power R&D programs are administered by the U.S. Department of Energy (DOE). At one time, electric power equipment manufacturers and electric utilities contributed a substantial share of joint funding with the Federal Government in a program of basic and applied research. Today, the private sector contributes little to public research and the DOE focuses on experimental R&D with potentially far-reaching impacts on generation, transmission and the environment. Major DOE experimental projects related to power generation include heat engines, pressurized fluidized bed combustion, magnetohydrodynamics, super conductors, and nuclear fission.

In the R&D cycle, government efforts may complement the short-term private sector objectives. Such is frequently the case in the aerospace industry. Boeing's C-5A design competition team, funded directly by the U.S. Air Force, did extensive windtunnel testing and structural analysis of large jet transport design concepts which resulted in the development of the 16-wheel high flotation main landing gear used in Boeing's commercial 747 today.

The trend in recent years in the amount of funds allocated to DOE by Congress for R&D has been mostly downward. This pattern is clearly seen in terms of the projects cited in Table 20.

In the superconductor generator project, DOE has funded about $8 million since 1974. In the past, the Electric Power Research Institute and another private firm each shared half of the cost of a superconductor project, but they subsequently cancelled the work.

The sharp decrease from 1983 to 1984 in DOE R&D funds for nuclear fission reflects elimination of the Clinch Valley Breeder reactor program. Fission research is actively performed in several large research centers. Fission holds considerable promise as an energy source in the early 21st century.

TABLE 20

DOE BUDGET FOR SELECTED R&D PROJECTS, FY 1982-85
(Millions of Dollars)

Project	1982	1983	1984	1985
Pressurized Fluidized Bed Combustion	25.0	12.5	7.5	5.0
Heat Engines.....	15.0	5.1	6.5	7.6
Magnetohydrodynamics.....	21.8	29.0	30.0	17.8
Nuclear Fission.....	1,107.0	995.0	372.0	328.0

Source: U.S. Department of Energy

In the long-run, the competitive health of the U.S. electric power generating equipment industry will depend on continued leadership in technology as well as productivity. The current low level of domestic demand for electric power generating equipment restricts the private sector funding available for R&D. Under these conditions, the U.S. Government could evaluate the benefits of continuing to fund and operate a strong basic experimental research program, could consider increasing funding for R&D projects such as those cited in Table 19, and could take steps to encourage expansion of private sector R&D. These activities all require funding, with implications for the government deficit. Cooperation between industry and government on R&D programs will help sharpen the U.S. competitive edge in world markets.

VI. FUTURE TRENDS

Future demand growth in the electric power generating equipment industry is expected to continue to be minimal through the 1990's. Future forecasts differ but the more current industry estimates indicate present excess production capacity in the industry is not likely to decrease in the next decade. If this is the case, which it seems to be, U.S. firms will have to become more agressive in order to acquire a substantial share of what little demand will exist. U.S. firms will have a difficult time maintaining profitability. However, with greater emphasis on repair and service, new technologies such as co-generation, and marketing in developing countries, some U.S. production capacity should survive until demand improves.

The U.S. industry's primary market has been its domestic market. With sluggish demand and increasing imports, no significant increases in demand are projected for the U.S. market in the 1990's. Thus, U.S. electric power generating equipment manufacturers will have to concentrate their marketing efforts even more on export markets. As developed nation markets are not expected to have substantial increases in demand and what demand there may be is virtually inaccessible to U.S. firms, the future markets for electric power generating equipment will be in the developing countries where competition for the most part will be between U.S. firms and IEA cartel members.

U.S. firms have the technology and products that these developing countries will want. However, while technological superiority is important in an electric power generating equipment purchasing decision, the total economic package of price and financing has become, and will continue to be, the key factor in determining which manufacturer wins a contract, particularly in developing countries. Several factors hinder U.S. firms from being competitive on price and financing and stand in the way of U.S. firms acquiring a significant share of developing nation business.

The high value of the U.S. dollar substantially increases the prices of U.S. electric power generation equipment in the world market. Until the value of the dollar declines relative to currencies of Japan and European countries, this significant disadvantage will continue to limit U.S. competitiveness.

The deteriorating financial condition of many of the developing countries also causes difficulties for U.S. firms in gaining a share of these markets. Many of the debt-ridden Third World countries rely on the International Monetary Fund and the World Bank for debt refinancing. As part of the refinancing package, the IMF and World Bank are requiring developing nations to cutback on imports. Consequently, the trend is toward more complicated and

extensive credit arrangements for those goods that are imported. Since many of our IEA competitors have close ties with their governments, they are better able to quickly arrange financial offers that meet the needs of foreign purchasers than are U.S. producers of power generating equipment. Arrangements offered by foreign governments include bilateral government protocols with special trade terms and financing, mixed credits and outright grants.

In addition to the disadvantages which U.S. firms face with regard to competing on a total economic package in developing countries, the IEA cartel, of which the U.S. is not a member, imposes another major problem for U.S. manufacturers. Through allocation of markets and contracts and setting of prices, IEA members are believed to seriously disadvantage U.S. competitors.

Even though technology has taken a backseat to price and financing, it will still be a factor of some importance in a firm or nation's future competitiveness. However, maintaining a technological edge will be difficult without sufficient orders generating adequate revenues to encourage the necessary level of R&D. In addition to developing the new technology, U.S. firms must also be willing to transfer technology to the purchasing countries, a trend that is becoming mandatory to remain competitive.

The following section suggests some ways in which the U.S. Government could help the industry improve its position in this increasingly competitive environment. However, most of the options require additional funding, which will contribute to the Federal Government's budget problems. Accordingly, the potential benefits of these options must be evaluated, not only with respect to the direct costs, but also with respect to other activities competing for government resources.

VII. FEDERAL POLICY OPTIONS

Summary of Issues

The power generating equipment industry is important to the U.S. economy, producing shipments exceeding $5.8 billion. It is also important to national security. Although electric power generating equipment, especially turbines and generators, is durable, long-lived equipment, the possibility exists for the destruction of significant power generating capacity in a national emergency. Reliable electric power supplies are key to operation of the production processes of other industries, including military critical industries, and to maintenance of minimally acceptable living conditions necessary in large urban centers. In addition, the domestic turbine industry also provides a technology base for U.S. Navy ship propulsion turbines. Movement offshore or shutdown of a significant amount of current domestic production capability would limit U.S. ability to respond rapidly in a crisis.

The electric power generating equipment industry faces an uncertain future. It is dependent upon the electric utility industry which, in turn, faces the most contentious environment in its history. To remain viable, the domestic equipment industry must maintain technological leadership and provide utilities with equipment to generate electricity less expensively than equipment offered by offshore manufacturers. They must do this at a time when demand is at record low levels with little likelihood of an increase in domestic requirements before the mid-90's. The power generating equipment industry cannot afford to lose any appreciable part of the domestic business during this time, and it needs critically to increase its participation in the international market.

A number of factors operate to make these objectives difficult to achieve. The most important of these are:

- -- high interest rates and the high value of U.S. dollar which contribute to the financing burden on foreign and domestic purchasers;
- -- lack of competitive export financing;
- -- low levels of domestic demand;
- -- limited access to markets;
- -- the "coming of age" of foreign firms matching/exceeding and becoming independent of U.S. technology;

High Value of the U.S. Dollar, High Interest Rates, and Competitive Financing

The relatively high value of the U.S. dollar increases the cost of U.S. equipment in competition with the equipment of foreign suppliers in both the U.S. and foreign markets. High interest rates affect U.S. industry by increasing the cost of borrowing capital and increasing the financing costs of domestic and foreign customers, thereby reducing demand. Policies to lower interest rates and exchange rate differentials are not likely to have immediate substantial remedial effects. However, other tactics might be adopted to counter these negative factors.

The electric power generating equipment industry's best opportunity to improve its exports is in the developing nations where need and, consequently potential demand, currently exists. A key element critical to success in these markets is export financing terms and conditions that match those of competitor nations. The U.S. Government has negotiated an agreement on export financing with OECD countries covering general exports and a specific export financing agreement on nuclear equipment. However, a difference in financing cost of 1 percent (i.e., an 11 percent vs. 10 percent interest rate) is equivalent to 15-20 percent of the contract price when applied to the usual repayment schedule for an export financed steam electric generating plant. In competitive export-financed power plant markets today, very low mixed credit rates prevail, not OECD consensus rates.

The most urgent need, in the eyes of the industry, is an early commitment by the U.S. Eximbank and the Agency for International Development (AID) to meet competitor financing on specific large projects involving mixed credits. In competitive export financed power plant markets today, low mixed credit rates are the norm. The absence of resources and a timely commitment forces U.S. multinationals to consider sourcing the production of major components in the facilities of nations that will provide early and competitive financing commitments.

Competitive export financing is a complex subject that merits further attention. To adequately assess the competitive effects of export financing, detailed information is needed on evaluated bid prices. At present, this information is lacking. Turning a competitive bid into an evaluated bid involves an analytical process which objectively considers bid prices, equipment efficiencies, financing terms and other important factors in estimating the expected cost of electricity from a proposed set of equipment.

OPTIONS:

- o Exim Bank could expand coverage to include local content portions of projects being financed.

- o Eximbank and AID could increase the use of mixed credit extensions and streamline the process.

- o U.S. Congress could extend to AID greater flexibility in how and in what countries it can apply its funds thereby releasing more funds for use in mixed credit financing arrangements or provide specific allocations for mixed credits.

- o A small team of qualified government and industry representatives could be organized to:

  a) obtain data regarding recent international competitive bids and their evaluation;

  b) identify specific reasons for contract award;

  c) recommend changes, as appropriate, in export financing programs.

Low Levels of Domestic Demand

As discussed earlier, domestic demand for electric power generating equipment is low. One way of improving the U.S. position domestically is to reduce import penetration in the U.S. market.

OPTIONS:

- o Investigate U.S. Government agency procurement practices, especially those of TVA and the Bureau of Reclamation, to determine if existing provisions/regulations such as the Buy American Act can be more effectively used to promote procurement of U.S. equipment when appropriate.[7]

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[7]According to a General Accounting Office study, "International Restraints to Competitiveness of the U.S. Heavy Electrical Equipment Industry," from 1977 to 1981, the Tennessee Valley Authority; Western Area, Southwestern and Bonneville Power Administrations; and Bureau of Reclamation combined purchased only $110.9 million of heavy electrical equipment; however, 51 percent of it was imported.

- o Encourage injured U.S. power generating equipment manufacturers to pursue anti-dumping cases when applicable and work with the U.S. Government to identify whether or not the lower price is the result of subsidy.

The current low level of domestic demand for electric power generating equipment not only inhibits the incorporation of technical advances by not providing adequate production volume for reliability testing, but discourages large producers like G.E. and Westinghouse from allocating R&D funds and severely restricts the funding available to smaller firms for R&D. It also limits the availability of capital or raises its costs to the industry because of low profitability or an uncertain future. To partially compensate for this problem, the U.S. Government could take certain measures to encourage R&D in the private sector.

OPTIONS:

- o Increase U.S. funding for R&D through EPRI, DOE projects, or the National Science Foundation. As a suboption, government could focus only on experimental generic technology excluding applied R&D.
- o Limit the responses to Government solicitations for development of technology to U.S. firms.
- o Continue the 25 percent R&D tax credit which is due to expire in 1985.
- o Establish a tax credit for industry support of university research.
- o The question has arisen whether current forecasts of growth of electric power consumption are accurate and whether power shortfalls are likely under current investment strategies. The U.S. Government could undertake a study of this issue.

Limited Access to Markets

The major barriers in Europe and Japan are subtle and based on the close relationship between governments and their electric utilities.

OPTIONS:

- Negotiate removal of both tariff and non-tariff barriers in developed countries. The GATT-sponsored Government Procurement Code, which establishes procedures that open government procurement to international bids, offers one avenue for multilateral negotiations. Government purchases of electric power equipment are not now covered under the Code. Negotiations are underway to broaden code coverage. One aspect of these negotiations is increasing the number of government entities subject to the code's discipline. In this context, signatories may consider bringing the major government purchasing entities of electric power generating equipment under the code. Because the barriers to U.S. exports to other developed countries are subtle, there is considerable skepticism concerning effective implementation of any agreement.

- The U.S. Government could also initiate bilateral discussions on market access. The "Trade and Tariff Act of 1984" grants a negotiating mandate for high tech industries and calls for an annual report on market access barriers to these industries. The "Trade and Tariff Act" also renewed the Generalized System of Preferences and added provisions encouraging developing country beneficiaries to relax barriers to trade.

- The U.S. Government could undertake a study of the degree of access U.S. suppliers have to European and Japanese markets, to identify overt and covert tactics of exclusion, if any, and to develop a plan for negotiating improved access with these countries and with developing countries that would include recommendations on appropriate forums.

  The United States has suggested a new round of multilateral negotiations under the General Agreement on Trade and Tariffs (GATT) to work towards greater liberalization.

The "Coming of Age" of Foreign Firms

In many export markets today, technology transfer is a condition of the sale. The successful bidder then becomes the sole source of imported units and components for 10 to 15 years. All major world suppliers offer technology transfer in these markets because none can afford to allow a competitor to gain the advantages of volume production. All else being relatively equal, the supplier with the largest volume will become the industry leader in cost and technology.

Through licensing of U.S. technology and domestic research and development, foreign competitors may advance their own technology to the point where it ultimately matches or even exceeds U.S. technology. If this happens, the U.S. share of future exports could suffer. One way of contending with this problem is to maintain aggressive research and development programs so that foreign competitors find it difficult to match/exceed U.S. technology. Options cited previously to promote R&D could be considered.

APPENDIX A

Products and Trade Classification Codes Included in Table 4

Tariff Schedule of the United States Annotated (TSUSA) Codes:

Conventional Boilers

6601010	Water tube stationary steam generating boilers
6601020	Other steam generating boilers, nec

Turbines & Turbine-Generator Sets

6602500	Steam engine and parts
6603020	Steam turbines
6603040	Steam turbine parts
6603500	Vapor power units nes and parts
6606200	Non-piston type engines nes (gas turbines)
6607400	Governors for water wheels, turbines and other water engines (hydro)
6607620	Water wheels, turbines and other water engines nes (hydro)
6607640	Parts of water wheels, turbines, other water engines (hydro)
6826005	Electrical generators exc. generator sets, not over 400 KW
6826015	Electrical generators exc. generator sets, over 400 KW, not over 10,000 KW
6826020	Generators 10,000 KW not over 40,000 KW
6826030	Generator over 40,000 KW
6826062	Parts, nspf, of generators

Products and Trade Classification Codes for Table 5

Schedule B Codes:

Conventional and Nuclear Boilers

6601006	Fuel rod assemblies
6601008	Nuclear reactors and parts
6601012	Boilers, not over 100,000 lbs of steam per hour
6601014	Boilers, over 100,000 not over 250,000 lbs steam
6601016	Boilers, over 250,000 not over 400,000 lbs steam
6601018	Boilers, over 400,000 lbs steam
6601024	Other steam generating boilers
6601040	Parts of boilers, exc heat exchangers
6601522	Economizers
6601524	Other boiler components, exc parts
6601526	Parts for boiler components

Turbines and Turbine Generator Sets

6603024	Steam turbines not over 5,000 hp
6603026	Steam turbines over 5,000 hp but less than 10,000 hp
6603028	Steam turbines 10,000 hp and over
6603040	Parts of steam turbines
6603600	Steam engines and other vapor power units and parts
6604965	Gas turbines for mechanical drives
6606820	Water wheels, water turbines and other water engines
6606840	Parts for water engines, inc governors
6826005	Generators, not over 400 KW
6826015	Generators, over 400 KW not over 10,000 KW
6826020	Generators, over 10,000 not over 40,000 KW
6826030	Generators, over 40,000 KW

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